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NOVEMBER, 1923

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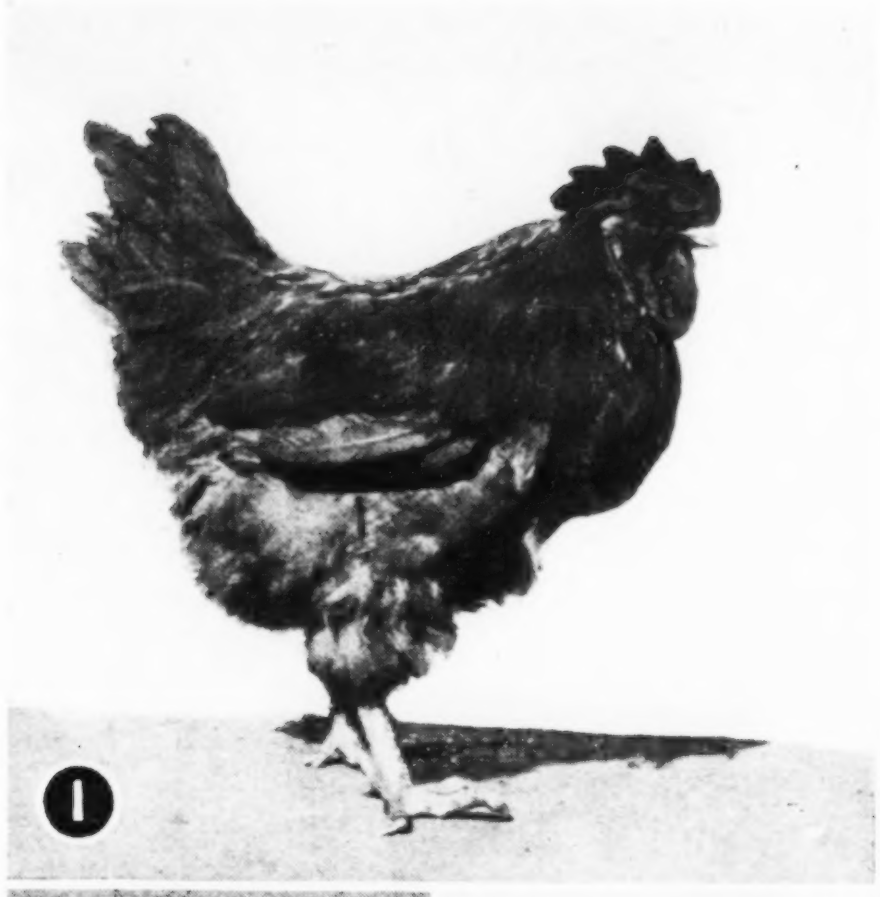
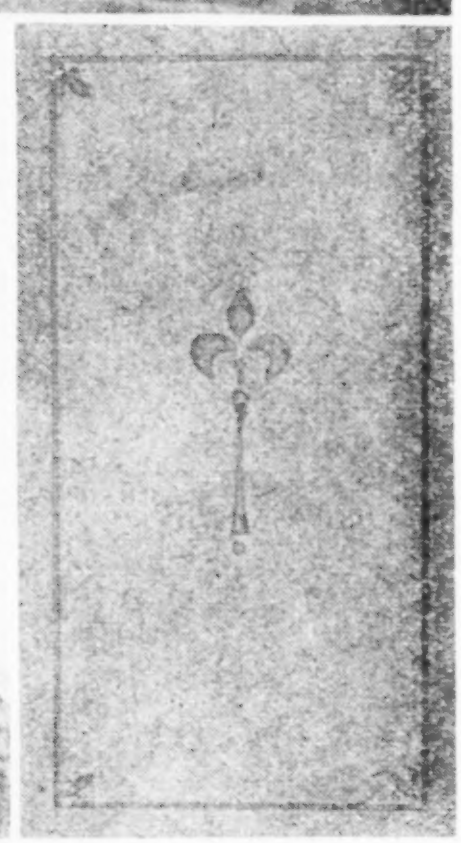
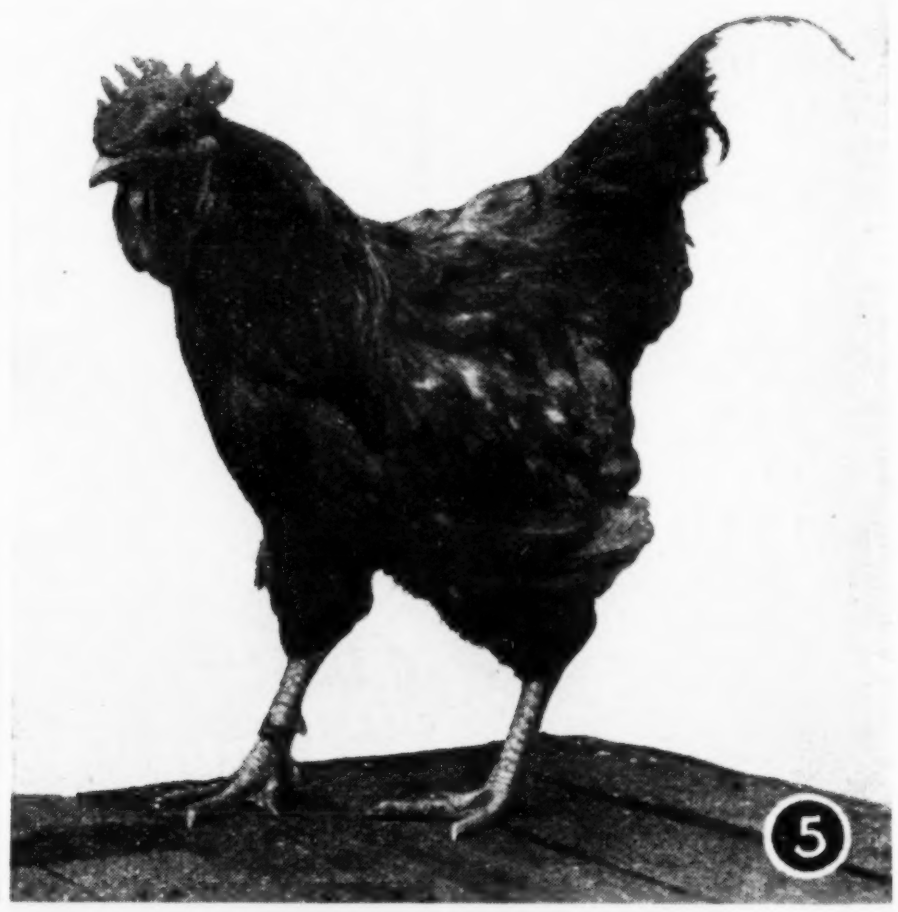






THE HEN THAT BECAME A ROOSTER

Four views of a hen that underwent complete sex-transformation, and one of her sons (No. 5), hatched in March, 1920, when she was functioning as a female. The photographs were taken at intervals as the change in sex was taking place: 1. On March 17, 1921; 2. On May 20 of the same year; 3. and 4. On February 24, 1922. Then, on July 7, 1922, two chicks were hatched, of which this "hen" was the sire. (Frontispiece.)

[See **Complete Sex-Transformation in the Domestic Fowl,** by F. A. E. Crew. Page 361.]

MENDELIAN ANALYSIS OF THE PURE BREEDS OF LIVESTOCK

I. The Measurement of Inbreeding and Relationship

SEWALL WRIGHT

Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.

THE pure breeds of livestock which we have today are the result of many years of patient effort. It seems likely that they will furnish the material for further improvement for many years to come. It should thus be of value to study the methods used in their development and attempt to express in terms of modern genetics what these methods should have accomplished, and what, in consequence, is the present genetic status of the breeds. Before dealing directly with the work of certain of the leading breeders it will be well to consider briefly the successive phases in the history of livestock breeding, the light which discoveries in genetics has thrown on the earlier breeding methods, and finally, the analytic methods by which the data in livestock pedigrees can be related to Mendelian theory.

Successive Phases in Livestock Breeding

Livestock breeders did not have to wait for the development of a science of breeding to accomplish a great deal in the improvement of livestock. From the first, indeed, there must have been modification of the wild types through the retention of those animals which were most tractable, and it was merely necessary for the early shepherds and herdsmen to come to a realization of the great fact of heredity, for the conscious molding of animal forms and function toward greater usefulness to man to commence.

Primitive man naturally made no distinction between innate differences between animals and those due to differences in care and feeding, and believing that all were equally transmissible, concluded that good care and liberal feeding were short cuts to livestock improvement. Numerous other beliefs, partially true or wholly false, such as those concerning the injurious effects of matings between close relatives, the effect of maternal impressions, telegony, and so forth, contributed to the traditional lore of breeding. The realization of the fact of heredity, aided indirectly by some of the other beliefs, was undoubtedly enough to lead to a very considerable improvement.

Intensive efforts toward the improvement of local types of cattle and sheep began in England early in the eighteenth century. After the leaders in this movement had reached a certain degree of success, they began to find difficulty in securing animals from other herds and flocks which did not have a detrimental influence. They began cautiously to breed within their own stocks. Such experiments were conducted most boldly by Robert Bakewell,[1]* who discovered that he could practice close and continued inbreeding not only without necessarily causing degeneration of his stock, but with a rapid fixation of the types for which he was selecting. Those seeing his Longhorn cattle and Leicester sheep could not but see the difference between them and the stock of his neighbors. Their uniformity of type brought

*For numbered references, see *Literature Cited* at end of article.

clearly to the eye their features of superiority.

Bakewell's example was followed with enthusiasm by other breeders and closely bred strains of the best local types of animals began to appear in all parts of England. The Colling brothers began following this system with the shorthorned cattle of the north of England. Their work was carried on by other breeders, notably by Thomas Booth and his descendants and by Thomas Bates, with whose methods we are to deal in a succeeding paper.

While many of these early breeders had notable success with close breeding, injurious effects seem to have been encountered with such increasing frequency in later years as to discourage the practice. The superior types which had been developed in each region, were, however, maintained and developed into the pure breeds as we know them. Herd and flock books were established for the recording of pedigrees. Efforts at improvement took the form of selection within these pure breeds and in the grading up of common stock by the continued use of purebred sires. This is essentially the status of the art of livestock breeding today.

During the last quarter of a century a real science of breeding has been developing about the principles of heredity discovered by Mendel. Mendelian heredity has been found to be the regular mode of inheritance for all sorts of characters and in all sorts of organisms. We have come to believe that it is the general law of heredity under sexual reproduction.

With accurate knowledge of the principles of heredity, the hereditary characteristics of many plants and of the small and rapidly breeding laboratory animals can be controlled with something of the precision of the chemist working with non-living materials. Livestock breed relatively slowly, however, and the large generations obtainable from laboratory animals are not feasible. Genetic analysis must thus be slow. Nevertheless, genetics has an important contribution to practical breeding in the insight which it gives into the results of the long-known mass methods of breeding: assortative and disassortative mating, selection and culling, inbreeding and outcrossing. This is particularly true in the case of inbreeding and outcrossing.

The Effects of Inbreeding and Crossbreeding

The principal effect of inbreeding, we find, is in automatically making homozygous some combination of the factors which were heterozygous in the original random-bred stock. Immediately related to this is the increase in uniformity in an inbred stock, which makes it possible to recognize genetic differences which would otherwise be overlooked. Increased prepotency in outside crosses is another direct consequence of increase in homozygosis. A usual but not necessary decline in vigor in all respects is explained as due to a tendency for recessive factors, brought to light by increased homozygosis, to be more frequently deleterious than dominant factors. This tendency in turn is explained as due merely to the greater rapidity with which natural selection can eliminate the deleterious dominant variations that arise in a random-bred stock. These conclusions and their interpretations have been tested with diverse kinds of plants and animals. Among mammals, Miss King's experiments[2] at the Wistar Institute with inbreeding and selection in a line of rats have shown clearly that inbreeding does not necessarily lead to deterioration. The experiments of the Bureau of Animal Industry[3] with twenty-three different inbred lines of guinea pigs have also demonstrated that even twenty-five generations of brother-sister mating may not cause any obvious degeneration. They have, however, demonstrated that some decline with inbreeding is the usual result in such characters as weight, fertility and vitality. They have also brought out a conspicuous differentiation among

different inbred lines in characters of the above kinds in which it has been almost impossible to demonstrate heredity otherwise. Another result has been the recovery of full vigor on crossing different inbred lines, explained as due to the complementary nature of these lines, each in general, supplying the particular dominant factors for vigor which had been lost in the other.

Characteristics differ greatly in the extent to which they are determined by heredity. Some, like most coat colors, are almost wholly hereditary. Others, like fertility and length of life are largely environmental as far as the individual is concerned. Inbreeding is as effective in making homozygous such heredity as there is in the latter case as in the former. Selection, on the other hand, is effective only in proportion to the importance of the hereditary element. The number of independent factors which effect the character also play a part in determining the effectiveness of selection methods. With knowledge of the effects to be expected theoretically from the various methods of breeding, in dealing with characters determined to any given extent by heredity, and showing any degree of segregation in the second hybrid generation as compared with the first generation, and showing any degree of dominance, it should become possible to lay plans on a sound basis for the best system of mating to follow to obtain the results which are desired with any particular character.

The application of even these methods to livestock improvement must necessarily, however, be a rather slow and expensive process. Meanwhile it is important to check them as far as possible by study of the methods actually used by those breeders who have been recognized as having been most successful and find out in terms of modern genetics just what it was that they did.

Importance of Skill in Judging

That the breeders who laid the foundations for the pure breeds were exceptional among their contemporaries as judges of livestock and thus exceptionally skillful in making matings between animals which were really superior, we may take for granted as a big element in their success. The importance which Thomas Bates attributed to his ability in this direction may be inferred from a quotation from a letter, "A hundred men may be found to make a Prime Minister to one fit to judge of the real merits of Shorthorns." We can form some idea of the ideals which these men strove for from the descriptions and pictures of the noted animals which they bred. Recognizing the importance of their ability as judges, it is nevertheless difficult to put a quantitative measure on what they accomplished by selection.

Measurement of Inbreeding

We can, however, discover by study of pedigrees how far they practiced inbreeding and how far they maintained a general resemblance to particular worthy animals by concentrating their blood. We need to use measures of inbreeding and relationship which shall make it possible to relate the methods of these breeders directly to the modern theory of genetics. Such coefficients have been described in a previous paper.[4]

The coefficient of inbreeding (F) depends primarily on the number and closeness of the ancestral connections between the sire and dam and secondarily on the degree of inbreeding of the common ancestors of the latter. Every chain of generations in the pedigree by which one may trace back from the sire to a common ancestor and then forward to the dam, passing through no animal more than once (within the given chain), contributes to the inbreeding an amount equal to one-half used as a factor one more time than there are generations in the

chain, with the qualification that this must be multiplied by a corrective term $(1 + F_A)$, in case the common ancestor (A) is himself inbred.*

It was demonstrated that this coefficient measures accurately the percentage departure from the number of homozygous factors in the random-bred stock toward complete homozygosis. If there were for example, 60 per cent homozygosis in the random-bred ancestral stock, a coefficient of inbreeding of 50 per cent means that the individual in question should be homozygous in 80 per cent of his factors.

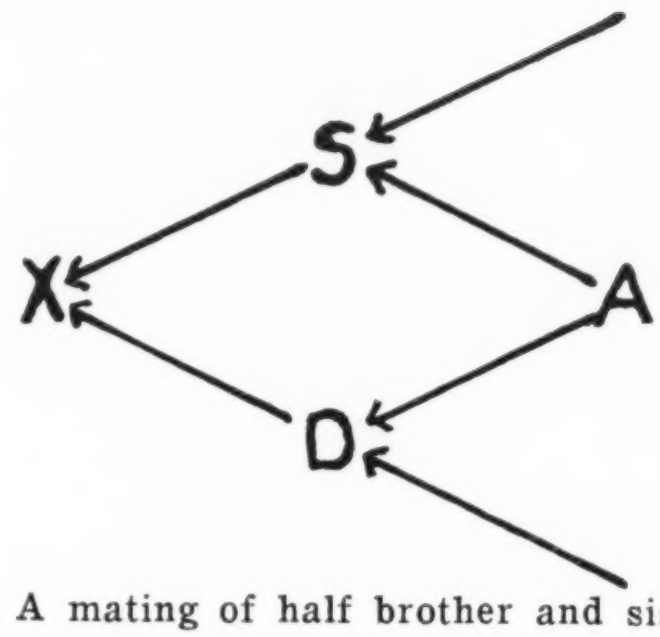
The method of calculation may be made clearer by a few examples. Let us take first the simple case in which a mating is made between half brother and sister (Figure 1a). The sire and dam are connected in only one way. There are two generations in the connecting chain, *S-A-D*. As the common ancestor (A) is not himself inbred, the formula is simply $(\frac{1}{2})^3$. The coefficient of inbreeding is thus 12.5 per cent.

If the sire is a grandson and the dam a daughter of the common ancestor (Figure 1b), there are three generations between sire and dam and the coefficient is $(\frac{1}{2})^4$, or 6.25 per cent.

If now the mating is between full brother and sister (Figure 1c), the lattter are connected by two chains, each containing two generations. The formula requires us to find the sum of the contributions of each chain. We have then $(\frac{1}{2})^3 + (\frac{1}{2})^3 = \frac{1}{4}$ or 25 per cent as the coefficient of inbreeding. With two generations of brother-sister mating (Figure 2a), the reader will readily see that sire and dam are connected

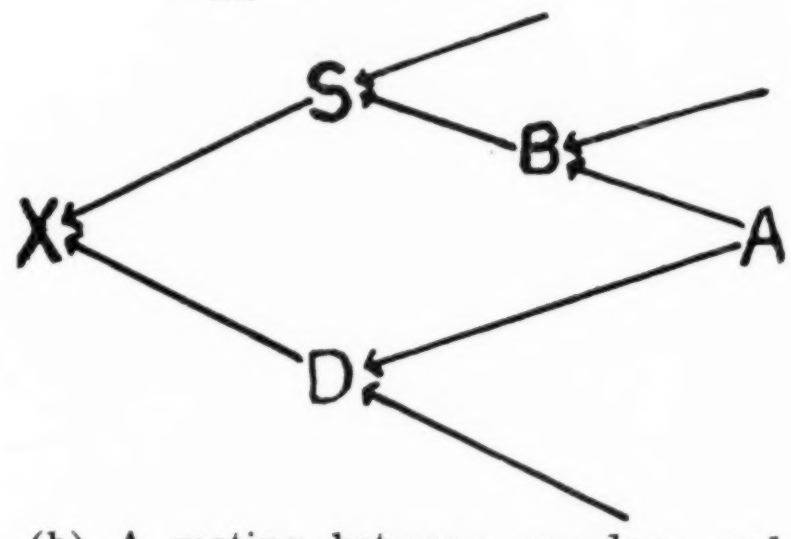
*Letting F_X and F_A be coefficients for the individual and for a representative common ancester of his sire and dam, and letting n and n' be the number of generations between the sire and dam respectively and their common ancester, we have as the general formula:

$$F_X = \Sigma\left[\left(\frac{1}{2}\right)^{n+n'+1}(1+F_A)\right]$$



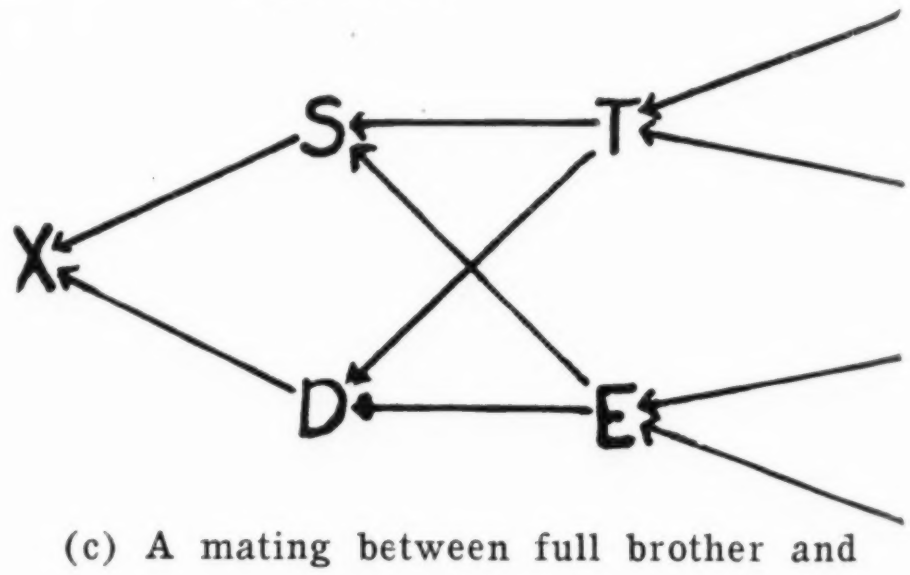
(a) A mating of half brother and sister

F_X=12.5%, R_{SD}=25%,
R_{XA}=47.1%



(b) A mating between grandson and daughter

F_X=6.25%, R_{SD}=12.5%,
R_{XA}=36.4%

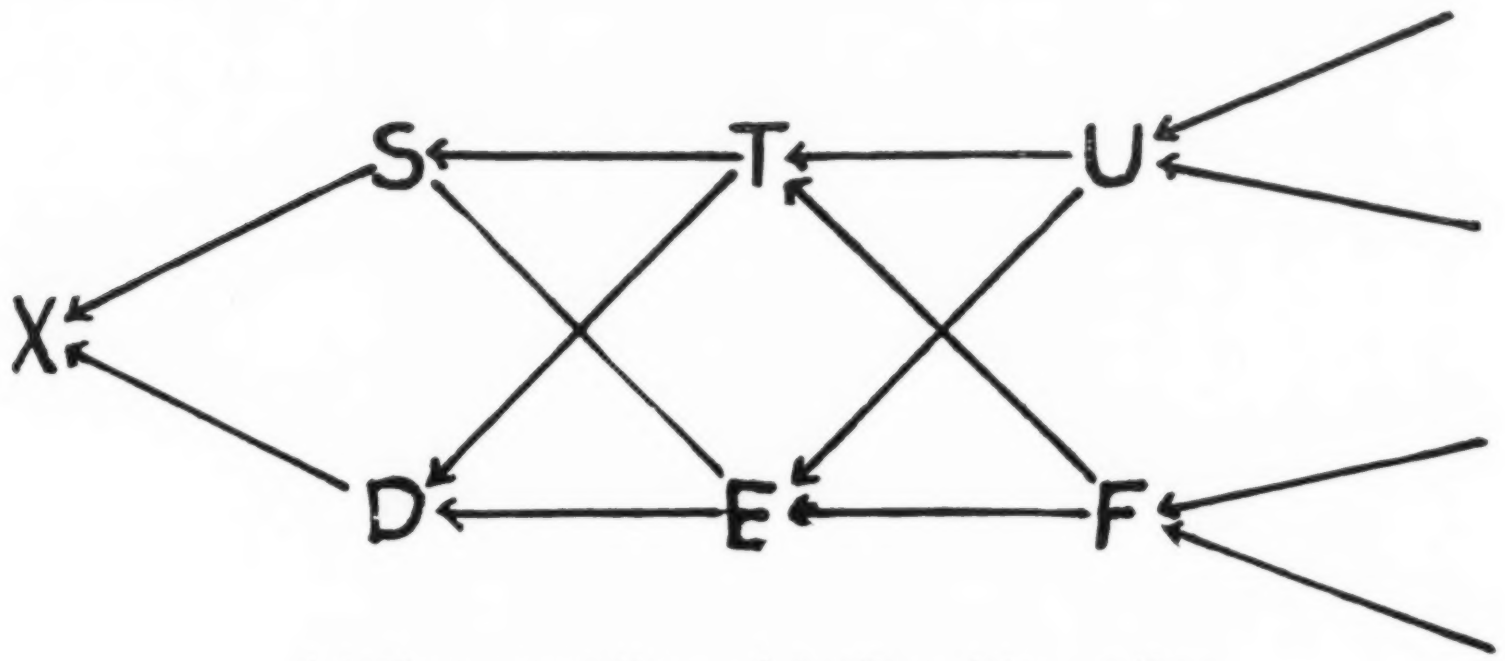


(c) A mating between full brother and sister

F_X=25%, R_{SD}=50%,
R_{XT}=44.7%

INBREEDING AND RELATIONSHIP

FIGURE 1. The chart shows three cases of inbreeding: mating of half brother and sister, mating between grandson and daughter, and mating of full brother and sister. The coefficient of inbreeding (F_X) of the resulting individual is given, in each case, also the coefficient of relationship between his sire and dam (R_{SD}), and between *X* and the ancestor to whom the inbreeding is due (R_{XA}). A coefficient of relationship of 50 per cent represents that existing between ordinary brothers and sisters.

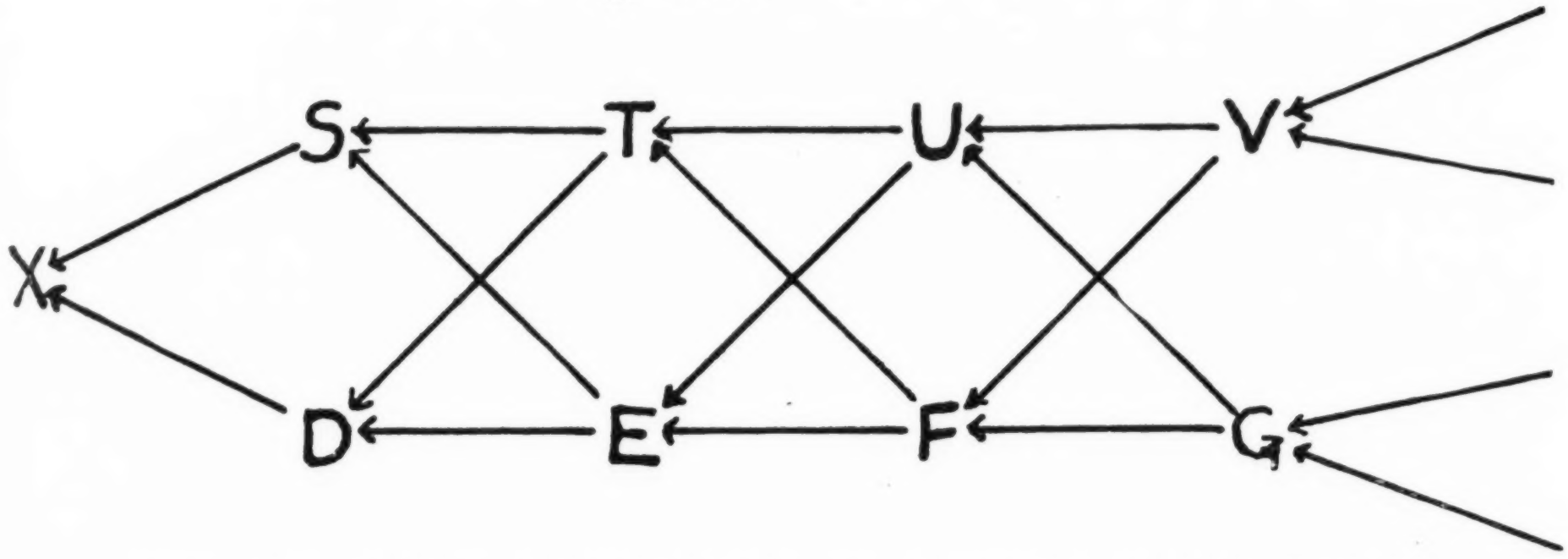


(a) Two generations of brother-sister mating

$F_X = 37.5\%$, $R_{SD} = 60\%$,
$R_{XU} = 42.7\%$

(b) Three generations of brother-sister mating

$F_X = 50\%$, $R_{SD} = 72.7\%$,
$R_{XV} = 40.8\%$

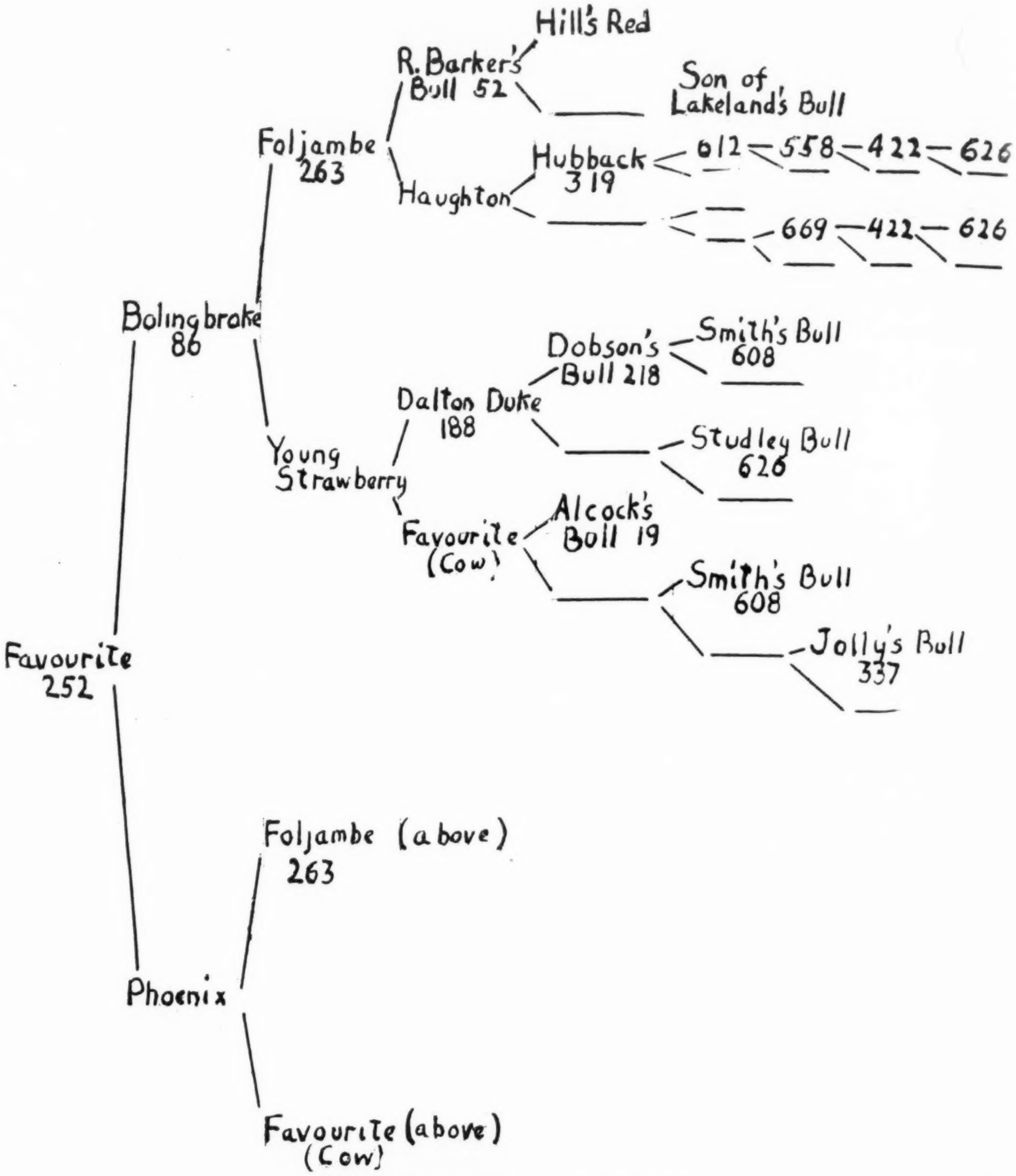


TWO AND THREE GENERATIONS OF BROTHER-SISTER MATING

Figure 2. For explanation of symbols see Figure 1. The effects of continued close breeding on homozygosis and resemblance due to relationship are analyzed in the text with the help of these diagrams.

through six independent chains, *S-T-D*, *S-E-D*, *S-T-U-E-D*, *S-T-F-E-D*, *S-E-U-T-D*, *S-E-F-T-D*. The formula is thus $2(\frac{1}{2})^3 + 4(\frac{1}{2})^5 = \frac{3}{8}$ or 37.5 per cent.

With three generations of brother-sister mating (Figure 2b) we encounter for the first time ancestors of the sire and dam which are inbred. There are as before two chains of two generations each by which sire and dam are connected through their parents, and in addition, four chains of four generations each, by which they are connected through their grandparents. Similarly we find eight chains of six generations each tracing to their great-grandparents. The parents of the sire and dam are themselves 25 per cent inbred, having one generation of inbreeding back of them. The formula thus becomes $2(\frac{1}{2}^3 \times 1.25) + 4(\frac{1}{2})^5 + 8(\frac{1}{2})^7 = \frac{1}{2}$. The individual *X* is 50 per cent inbred. The reader will have no difficulty in carrying the results to further generations and discovering that the limit under indefinitely continued inbreeding is 1, complete homozygosis, as it should be according



PEDIGREE OF FAVOURITE

FIGURE 3. Charles Colling's bull, Favourite 252, might be considered the foundation bull of the Shorthorns, as his blood became more widely distributed in the developing breed than that of any other bull. Favourite was inbred to a considerable extent, 19.2 per cent, which means that he was 19.2 per cent less heterozygous than the random-bred foundation stock. As an illustration of his influence in the early history of the breed it may be mentioned that forty years after Favourite's death there was a closer relationship between him and the cows of the famous Dutchess strain, bred by Thomas Bates, than between ordinary parent and offspring.

to theory. The results in regular systems of breeding, such as continued brother-sister mating, it should be said, can be worked out much more simply by special methods.[5] The case is merely brought up here to show the application of the general formula which must be used in dealing with the irregular systems encountered in ordinary pedigrees.

The Pedigree of Favourite

As an example of such an irregular case, let us take the pedigree of the bull Favourite (Figure 3). None of the ancestors of the sire and dam (Bolingbroke and Phoenix) are shown as inbred, so that we merely need to count the generations in each path connecting sire and dam, add one and use as an exponent of ½ to obtain the contribution of each path to the coefficient.

We find that Foljambe was the sire of both Bolingbroke and Phoenix. The contribution due to this connection is thus $(\frac{1}{2})^{3}$ or 12.5 per cent. Foljambe as Bolingbroke's sire is not connected with the dam of Phoenix. This disposes of all possible connections through Foljambe as the sire's sire. The sire's dam, Young Strawberry, is connected twice with Foljambe as the dam's sire through common descent from the Studley Bull (626). The latter is four generations back of Bolingbroke and seven back of Phoenix in each of two lines through her sire. These contributions are thus $(\frac{1}{2})^{12} + (\frac{1}{2})^{12}$ or 0.05 per cent, an almost negligible quantity. We have finally to consider the connections between sire's dam (Young Strawberry) and dam's dam (Favourite Cow). First we note that Favourite Cow was herself the dam of Young Strawberry. We have here a contribution of $(\frac{1}{2})^{4}$ or 6.25 per cent. The sire of Young Strawberry is connected with Favourite Cow through descent from Smith's Bull. The contribution is $(\frac{1}{2})^{8}$ or 0.39 per cent. This disposes of all connections. The work may be arranged as follows:

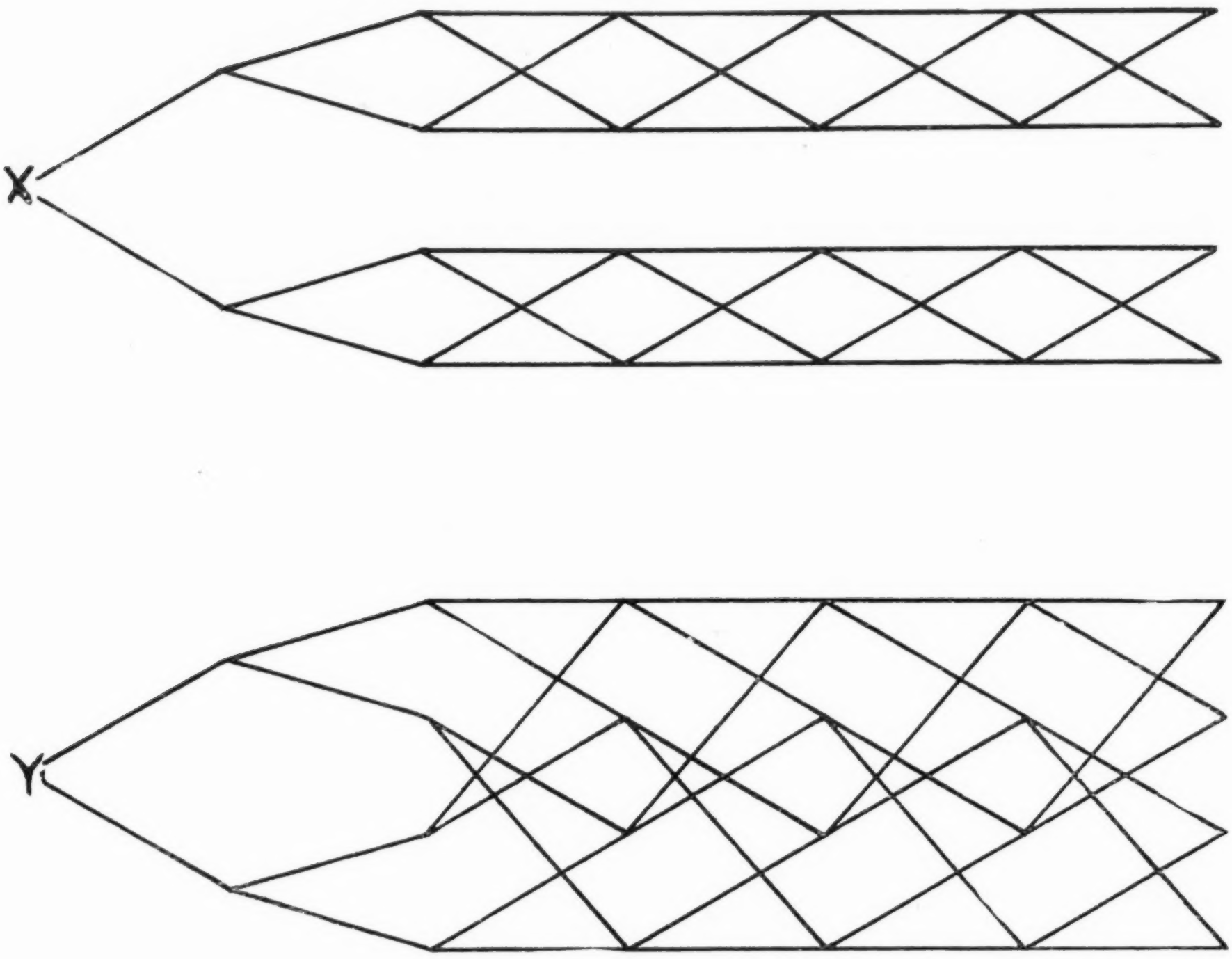
Inbreeding of Favourite (252)

Common Ancestor		Generation from		
Name	Inbreeding	Bolingbroke	Phoenix	Contribution
Foljambe	0	1	1	12.50
Studley Bull	0	4	7,7	0.05
Favourite Cow	0	2	1	6.25
Smith's Bull	0	4	3	0.39
Total				19.19

The total percentage of inbreeding is 19.2. It will be noticed that this would not be appreciably modified by omission of the remote connections through descent from Studley Bull and Smith's Bull. This coefficient means that Favourite departs 19.2 per cent from the genetic heterogeneity of the foundation Shorthorn stock in the direction of complete genetic homogeneity in other words has 19.2 per cent less heterozygosis.

Comparison with Other Measurements of Inbreeding

As the coefficient of inbreeding is derived from theoretical considerations, it will be well to consider for a moment how it is related to the degree of inbreeding in the popular sense. This is a somewhat difficult question to answer since inbreeding in the popular sense is a rather vague term. Pearl[6] has defined inbreeding on the basis of the ratio of the number of ancestors in each ancestral generation to the maximum possible number. The smaller the ratio the greater the inbreeding. This is a very different conception from the writer's, which is based on the reduction of genetic heterogeneity present in the foundation stock and is hence in the main a function of the ancestral connections between the parents. The contrast in the two conceptions can be seen very clearly by comparing the two pedigrees of Figure 4. The upper represents a mating be-



TWO METHODS OF BREEDING

FIGURE 4. Two pedigrees in which the number of ancestors in each generation remains the same, but in which the coefficient of inbreeding (F) of the individual X equals 0, while that of Y approaches 100 per cent. This is in accord with the results of experiments in inbreeding, where crossing two weakened inbred lines results in the return of normal vigor. Methods of calculating inbreeding that are based only on the ratio of the number of ancestors in each generation to the greatest possible number would not bring out this difference.

tween two individuals, each of which comes from a line in which brother-sister matings have been made generation after generation. The other comes from a line in which double first cousin matings have been made for generations. In each case there are two parents, four grandparents, four great grandparents, and four in every ancestral generation to the point where inbreeding commenced. They both, therefore, have the same very high coefficient of inbreeding according to Pearl's formula. According to the writer's formula, on the other hand, they are nearly as different as possible. The former has a coefficient of 0, the latter of nearly 1. The former is heterozygous in all respects in which the ancestral lines differ; the latter approaches perfect homozygosis.

With respect to vigor, the experiments of the Bureau of Animal Industry with guinea pigs, already referred to, demonstrate that the crossing of two weakened inbred lines results in a recovery of the vigor that has been lost. Thus generally speaking, the animal X (Figure 4), would be a vigorous animal; the animal Y would be weak in various respects. The experimental evidence is thus in accord with the coefficients 0 and 1 while as far as the writer knows there is no experimental evidence to indicate that the number of ancesters *per se*

has anything to do with the uniformity, vigor, prepotency or other characteristics.

Even if the measurement of inbreeding is based on the ancestral connections between sire and dam, there remain many possible formulae which could be suggested.

Perhaps the first thought would be to base the coefficient on the percentage of common blood in sire and dam. A little consideration will show, however, the unreliability of such a measure. Full brother and sister have 100 per cent common blood, but we know that much greater effects can be produced by continued brother-sister mating than appear in the first generation. Indeed, there might be 100 per cent common blood with no common ancestors of sire and dam for an indefinite number of generations. Let us suppose that the sire and dam trace to the same 1,024 individuals ten generations back, but have no common ancestors in later generations. Common sense and experiment tell us that their progeny could hardly be considered to be inbred at all. The coefficient of inbreeding of their progeny comes out only $1024 \times (1/2)^{21} = (1/2)^{11} = 0.05$ per cent in spite of the 100 per cent common blood.

Pearl[6] has attempted to separate from the amount of inbreeding as found by his formula a portion due only to relationship between the parents, this relationship being based on the number of animals common to the pedigrees of sire and dam in proportion to the greatest possible number of common ancestors. This comes closer to the writer's conception of inbreeding but in practice gives very different results from that given by the coefficient F. For example, continued mating of single first cousins gives results rapidly approaching 100 per cent according to this or any other of Pearl's coefficients, while the percentage of heterozygosis is decreased only by about 25 per cent in ten generations ($F = 25.2\%$). As far as the writer knows there is no purely experimental evidence to determine whether such a system as continued mating of single first cousins really approaches the effect of brother-sister mating in a few generations or whether it has the relatively slight effects indicated by the value of F. The writer, however, has sufficient confidence in the generality of Mendelian inheritance to believe that it is an advantage to use a coefficient which measures directly the consequences logically to be expected from it as well as measuring accurately the results of experiments in inbreeding and crossbreeding as far as these have been carried.

Measurement of Relationship

The measurement of relationship* is naturally closely related to measurement of inbreeding. In order to meas-

*Following is the formula where n and n' are the generations from the individuals X and Y to a given common ancestor A, and F_A, F_X and F_Y are the coefficients of inbreeding of A, X and Y respectively:

$$R_{XY} = \frac{\Sigma\left[\left(\frac{1}{2}\right)^{n+n'}(1+F_A)\right]}{\sqrt{(1+F_X)(1+F_Y)}}$$

In the important case of sire and dam of the individual X we have:

$$R_{SD} = \frac{2F_X}{\sqrt{(1+F_S)(1+F_D)}}$$

Thus if the sire and dam are related but not themselves inbred, the coefficient of relationship is just twice the coefficient of inbreeding of their progeny.

ure the relationship between animals in such a way that direct comparison can be made with Mendelian theory, the most satisfactory method seems to be to find the coefficient of correlation to be expected with respect to a character determined wholly by heredity with no dominance. Such conditions give the maximum correlation and any other conditions give results strictly proportional. The correlation between parent and offspring or between full brothers should be 0.50 in such cases, according to Mendelian theory, in close agreement with many actual determinations. The correlation to be expected when the relationship is more complex can readily be calculated.[5]

Literature Cited

[1] The statements in regard to the early history of the Shorthorn cattle are largely drawn from *Shorthorn Cattle* by Alvin H. Sanders and *Farm Livestock of Great Britain* by Robert Wallace.

[2] KING, HELEN DEAN, 1919. Studies on Inbreeding. The Wistar Institute of Anatomy and Biology, 175 pages. Reprinted from the *Journal of Experimental Zoology*. 26:1-98; 27:1-35, and 29:134-135.

[3] WRIGHT, S., 1922. The Effects of Inbreeding and Crossbreeding on Guinea Pigs. *Bulletins* 1090 and 1121. U. S. Department of Agriculture.

[4] WRIGHT, S., 1922. Coefficients of Inbreeding and Relationship. *American Naturalist*, 56:330-338.

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MENDEL "COMES BACK"

Scheduled to Attend World Dairy Congress with McCullum and Other World Famous Specialists in Dairy Science

There is to be a world dairy congress in Washington October 2 and 3, adjourned to Philadelphia for October 4, and to Syracuse, N. Y., October 5 to 10. This congress will be attended by the world's most famous specialists in dairy science.

There will be delegates here from practically every country of Europe, South America and Australia. Most of them will be men of national reputation, and many of international fame. There will be leaders in science, including Mendel, who discovered the astounding law of breeding and crossbreeding, and McCollum, who discovered the most revolutionary element of nutrition, known as "vitamins," without whose presence in food all nutrition is valueless and leads only to disease and death. Vitamins were unknown prior to 1912; today physicians and dieticians who are not informed as to their essential activities are not competent to practice medicine or prepare food.—*Washington Star.*

HERITABLE CHARACTERS OF MAIZE

XVI—Dead Leaf Margins

J. H. KEMPTON
U. S. Department of Agriculture, Washington, D. C.

DEAD leaf-margins is a character which becomes noticeable about the time the tassel appears, but before the flowers are mature. It affects the upper six to eight blades usually embracing a leaf or two below the ear node. The dead band varies in width from two to twelve mm., often wider at or near the base of the leaf, depending upon the intensity of expression. It is very conspicuous at flowering time when the leaves are fresh and green, but notwithstanding this fact was not noted until through chance a homozygous progeny was grown.

The leaves of most normal corn plants if allowed to dry usually wither first at the tips, the whole process being gradual, though it follows from the shape and structure of the leaf that the tissue dries more rapidly along the margins than along the midrib. However, with some plants the leaf margins are the first to wither and the blade gradually dries toward the midrib. The leaves of the variation *dead margins* would be confused readily with this latter form of drying, especially if seen late in the season, but the dead marginal tissue of the variation is apparent when the plant is at its maximum vigor and there should be no uncertainty if the plants are examined at the time of flowering.

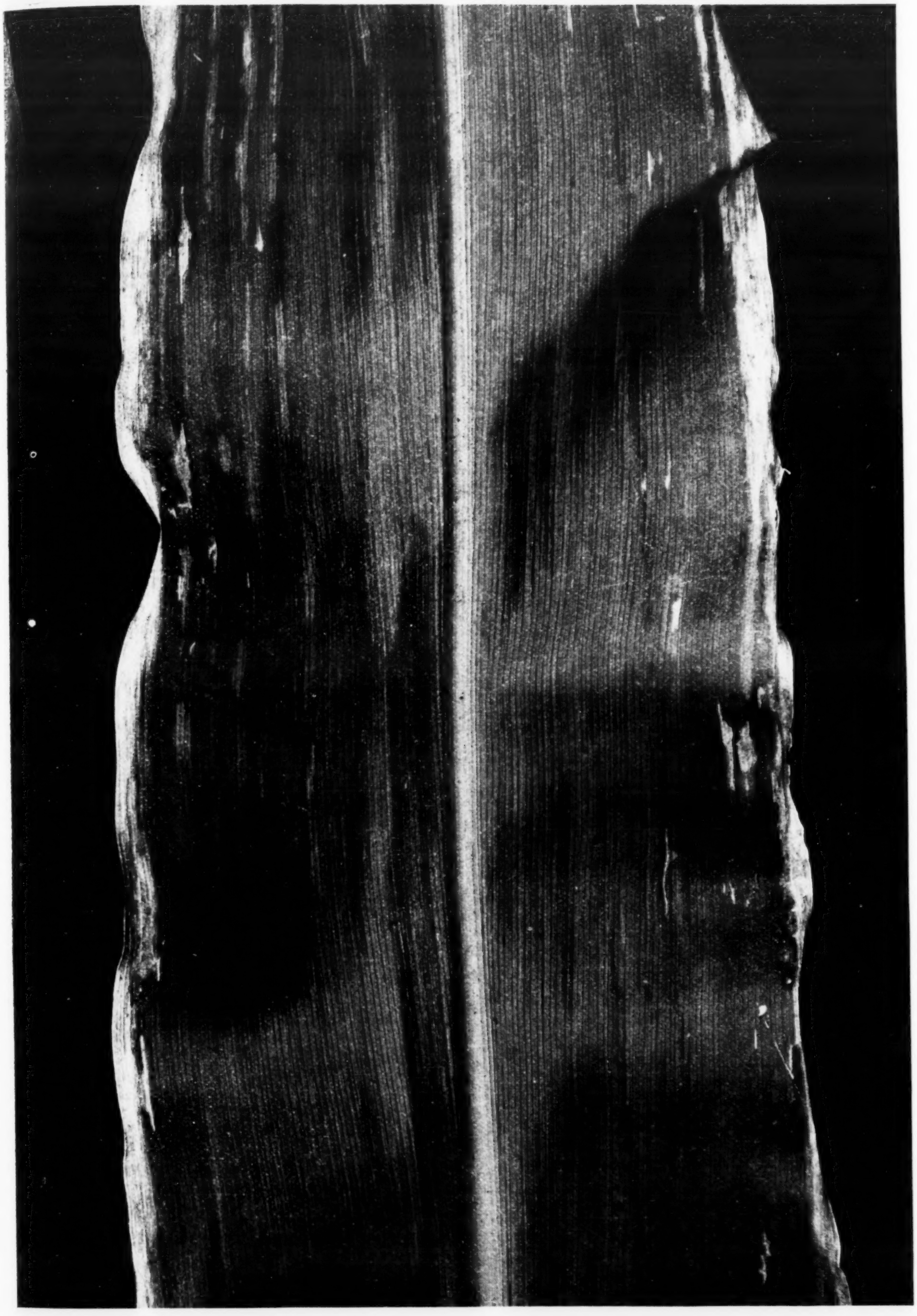
The strain now designated *dead leaf margins* was noted as a homozygous progeny in 1920. Its ancestry for five generations is known, but only the two generations preceding 1920 were the result of self-pollination, the others being crosses between sibs. The strain is descended from a hybrid between the Stowell's Evergreen variety of sweet corn and a dent variety from Southern Texas known as Brownsville. The hybrid was made at Victoria, Texas, in 1912 by J. H. Kinsler to develop a worm-resistent sweet corn.[1] Numerous lines of this original hybrid have been grown and the present is one of a number included for the study of various abnormal forms. Crosses have been made between plants showing the dead margin character and ten or fifteen other well-known aberrant forms. From the behavior of these crosses it seems that in addition to the character *dead margins* the progeny is affected with some lethal factor as many of the hybrid seeds fail to grow. Four hybrids, however, were grown successfully and all had normal leaves in the first generation while in the second generation dead leaf margins reappeared in approximately twenty-five per cent of the plants, though with a wide range in variability which reduces the reliability of classification. The classes for all four hybrids were 440 normal, 138 dead margins, the percentage of dead margins being 23.9 ± 1.2. From the nature of the character the plants must be classified at or before flowering time so that the character *dead margins* will not be confused with the natural death of the leaves.

From an analysis of small progenies *dead margins* seems to be unrelated genetically to brachytic culms, ramose inflorescence, sweet endosperm, sun red plant color, two factors for lineate leaves, and a chlorophyll disorder, yellow leaf spot.

[1]Breeding Sweet Corn Resistant to the Corn-Ear Worm. COLLINS, G. N. and J. H. KEMPTON. *Jour. Agri. Research.* Vol. XI, No. 11, pp. 549-572. December 10, 1917.

NORMAL AND "DEAD LEAF MARGIN" TYPES OF MAIZE

FIGURE 5. The plant at the left has just started to shed pollen, while the silks have not yet appeared. The upper eleven leaves on this plant show dead margins, the plant having produced a total of twenty leaves.



MAIZE LEAF WITH DEAD MARGINS

FIGURE 6. Natural size section of the blade of a maize leaf showing dead margins. The leaf margins of the upper blades die before the plant flowers, but the remainder of the blade completes a normal cycle.

Name	Birth	Death	Marriage	Consort	Rem.
BURRITT					New Britain, Conn.
Elihu	13 Dec., 1765	29 Jan., 1827	20 July, 1793	Elizabeth Hinsdale (Elijah)	
P1 Elihu Up	24 Dec., 1732	19 Mar., 1793	1794	Eunice Wakeman (Stephen)	
F1 Elijah Hinsdale	20 Apr., 1794	3 Jan, 1838	28 Oct., 1819	Ann W. Watson (John)	++
Elizabeth	22 July, 1796	1872	24 Aug., 1829	Hezekiah Seymour	+
Emily	12 Aug., 1798	1839	1838	Taylor	+
George	5 Dec., 1800	22 Aug. 1822	unm.		
Mary	18 Feb., 1803		26 May, 1825	Wm* Williams	+
William	8 July, 1805		5 May, 1826	Clarissa Cole ( )	+
1522C	31 May, 1808		16 Oct., 1832	Nancy Barnes (Selah)	s.p.
Elihu	8 Dec., 1810	9 Mar., 1879	unm.		
Eunice Wakeman	2 May, 1813		1st 24 Apr., 1833	Jabez Cornwell	s.p.
" "			2d 17 Mar., 1853	A. J. Sawyer	++
Almira Bidwell	27 July, 1816		24 Nov., 1836	Stephen L. Strickland	+-

* Andrews says Warren Williams

FAMILY PEDIGREE CARD—AS FILLED OUT

FIGURE 7. The family name appears at the top of the card. On the second line is entered the name of the male head of the family listed below, Elihu Burritt, born December 13, 1765. On the third line appear data regarding Elihu Burritt's father, born in 1732. Below the heavy line are listed the names of the children of Elihu Burritt and Elizabeth Hinsdale Burritt. Each card represents a family unit, and the universal adoption of such a system would make every card part of a record of human relationship that could be expanded indefinitely, to embrace the families of a country, or even of the entire human race.

A UNIVERSAL CARD SYSTEM FOR FAMILY PEDIGREES

HOWARD J. BANKER

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PRACTICALLY every genealogist has his own method for keeping track of the ramifications of the family network with which his studies are concerned. The inventions are numerous and sometimes remarkable and each worker is prone to believe that his own device is the best, or at least he has become so entangled in his system that it is impracticable for him to make any change.

Some of these schemes are too complicated or even bizarre to be of use to anyone but the inventor, others are cumbersome and unwieldy for ready reference, nearly all possess a degree of rigidity that materially limits their usefulness. Charting systems on any extended scale are cumbersome, permit little interpolation, and are limited to special lines of research. While of great value within their limitations for depicting final results, they are impracticable for use as a working guide for the general genealogist, except in very restricted fields. Systems of numbering are popular and these are highly efficient in certain cases. They are often devised to permit indefinite expansion and interpolation as the work proceeds and are simple to manipulate, but their use is restricted to special phases of genealogical research. One system of numbering is used for tracing ancestral lines, while a different system must be employed for lines of descent, and I know of no such system that will provide for all the lines of collateral relationship.

Believing there are many who are striving to find some more satisfactory method of ready reference that will guide them through all the labyrinth of family relationships, this paper has been written, trusting that the experience of the writer may be of some value to others. When we consider the complications in family relationships that may and often do arise from intermarriages, it is evident that no system can be devised that will be so simple that it will not require some study in its application. In other words, it is not possible to make such a system so mechanically perfect that it will be "fool-proof."

After years of practical work, the writer has developed what he believes to be the simplest possible system applicable to large and complicated family pedigrees. It is a card system capable of any amount of interpolation or expansion, and yet permitting at all times the ready tracing of the relationship of every individual to every other, if the connecting links have been properly recorded. In fact, it is conceivable that a genealogist specializing in some locality, could build up such a system that would furnish him with a complete synopsis and ready reference index to every family and individual in his field. Theoretically, if accurate data could be obtained, the entire human race could be included in a single, though enormous, system of related cards. Indeed, every collection of cards on this plan is a fragment of such a universal system, hence I have called this a "Universal Card System." If the plan were generally adopted and consistently maintained, it would be possible eventually to combine the card collections of many independent workers, without any change, into a single series. The only disadvantage being

Name	Birth	Death	Marriage	Consort	Rem.
BURRITT					
Elihu	bp 24 Dec, 1732	19 Mar, 1793	1749	Eunice Wakeman (Stephen)	
P1					
F1 Polly	1750	3 Nov, 1823		Joseph Mather	+
Elijah					
Naomi	1761	12 Jan, 1853	1790	Noah Stanley	+
Isaac	1762	16 Mar, 1766			
Elihu	13 Dec, 1765	29 Jan, 1827	20 July, 1793	Elizabeth Hinsdale (Elijah)	++
Wakeman				Amelia Banks ( )	

ELIHU BURRITT'S FATHER'S FAMILY

FIGURE 8. The father of the family whose card is shown in Figure 7 is the fifth son, and his identity can be determined, in case of other individuals of the same name, by reference to dates of birth, death and marriage. It was not possible to trace the Burritt line any farther than this, so the third line is blank. Under the column headed "Remarks" are entered various reference marks useful to the worker. One plus sign indicates that the married children had families. Two marks indicate that these families have been carded. S. P. shows that there was no issue.

Name	Birth	Death	1st Marriage	Consort	Rem.
HINSDALE			2d	Ruth Bidwell (James)	
Elijah	1 Apr. 1744	26 June, 1797		Sarah Daniels	
P1 John	13 Aug. 1706	2 Dec., 1792	8 Nov. 1733	Elizabeth Cole (Nathaniel)	
F1	By 1st wife				
Ruth	bp 30 Dec. 1770	d.y.			
Elizabeth	6 Feb. 1775		20 July, 1793	Elihu Burritt	++
Roxana	10 June 1778			Ezekiel Andrews	+
	By 2d wife				
Sarah					
Ruth					

ELIHU BURRITT'S WIFE'S RECORD APPEARS ONLY ON HER FATHER'S CARD

FIGURE 9. To avoid duplication the women are not listed on separate cards, but appear only on the cards of their husbands and fathers—an arrangement that would not meet the approval of the Womans' Party. Thus, in filling out the cards it is necessary to enter the name of the woman's father after her name on her husband's card.

that in such case there might be found some duplication, which, however, could be easily corrected by simply discarding the more imperfect duplicates. In this way the material built up as the life work of one genealogist would have a high value to any other person working under the same system.

How the System Works

The system can best be explained by illustrations. Standard 5x8-inch cards, like those used in many card systems, are ruled as shown in Figure 7. This represents a typical card as filled out. Each card contains the record of a family group and its title is always determined by the male head of the family, whom we may term the propositus. On the topmost line at the left is printed in clear letters the surname of the family, in this case Burritt, and this is understood as pertaining to all in the column headed "Name." It is especially important

that this name be printed very distinctly. On the next line below is entered the given name of the propositus or head of the family, Elihu, and to the right the dates of his birth, death and marriage, as indicated, and the name of his wife, Elizabeth Hinsdale, which it is to be observed, is followed by the given name of her father in parentheses. The reason for this will appear later. On the next line marked "P_1" (that is, first parental generation), is entered the given name of the father of the propositus with his dates and consort as before. If he had more than one wife, only the name of the mother of the propositus should be entered here, in this case Eunice Wakeman, daughter of Stephen Wakeman.

Below the heavy line beginning at "F_1" (that is, first filial generation), are entered in succession the children of the propositus, with the proper data, if known. The names of female consorts should always be followed by the father's given name in parentheses, if it is known, but this is not necessary in the case of male consorts. Those who married more than once should have the record of all consorts given in succession as is shown for the ninth child, Eunice Wakeman Burritt, who married first Jabez Cornwell, and later A. J. Sawyer.

The column headed "Rem." may be used for various reference marks to serve the purpose of the worker. The writer has found it convenient to indicate whether the married children had families, the plus sign indicating that there were children, the double plus that the family has been carded, and s. p. that it is known that there was no issue. The cards provide sixteen lines for the record of children and it is rare that the space is not ample. In those few instances where more space is required it is best to carry the names "over" to the back of the card rather than use a second card. Usually there is room enough on the lower part of the card to enter footnotes, if desired, calling attention to variations in data. References to sources are conveniently entered on the backs of the cards, but the cards should not be used for general genealogical information. Such material should be entered on sheets in suitable folders.

It is evident that such a card may be filled out for any man and his immediate family and it is not necessary to pay the least attention to remoter relationships. If a collection of such cards is made covering a family or a community for several generations the relationships must all eventually appear. Cards are necessary only for males who had children. The compilation of the cards is, therefore, a very simple matter.

To see how the system works, let us suppose that we wish to trace the ancestry of Elihu in the Burritt line. His own card, Figure 7, shows that his father was another Elihu. Turning then to his father's card, Figure 8, which can be distinguished from others of, perchance, the same name, by the date of birth, name of consort, or other data, we find that there is no further record of the Burritt ancestry. The paternal grandparents are not known, but we do find the names of the father's brothers and sisters and their consorts and other data.

Let us now try a female line. We wish to know the ancestral connections of the consort of the propositus. Figure 7 shows that the consort of Elihu Burritt was Elizabeth Hinsdale and that her father was Elijah Hinsdale; we therefore turn to Elijah Hinsdale's card, Figure 9. If there are several Elijah Hinsdales carded, we can identify the correct one by observing that this Elijah Hinsdale had a daughter Elizabeth who married Elihu Burritt, and the date of marriage is confirmatory. Figure 9 shows that the father of Elizabeth married twice and that she was a daughter of the first wife, Ruth Bid-

Name	Birth	Death	Marriage	Consort	Rem
BURRITT					
Elijah Hinsdale	20 Apr., 1794	3 Jan., 1838	28 Oct., 1819	Ann W. Watson (John)	
P. Elihu	13 Dec., 1765	29 Jan., 1827	20 July, 1793	Elizabeth Hinsdale (Elijah)	
P. Elizabeth	22 Apr., 1822	28 Oct., 1826			
George Hinsdale	28 Feb., 1825		20 Oct., 1849	Maria L. Parsons ( )	++
Anna Elizabeth	30 Nov., 1829		19 Apr., 1860	Joseph B. Hawkes ( )	+

THE FAMILY OF ELIHU BURRITT'S ELDEST SON

FIGURE 10. Elihu Burritt's son, Elijah (Figure 7) married Ann W. Watson, whose father was John Watson. They had three children, two of whom married and had families.

Name	Birth	Death	Marriage	Consort	Rem.
SAWYER					
A. J.			17 Mar., 1853	Eunice Wakeman Burritt (Elihu)	
P.					
P. Alonzo Burritt	11 Feb. 1854				
Clarnes Hosmer	5 Aug., 1857				
Grace Alice	4 June, 1860				

FAMILY OF ONE OF ELIHU BURRITT'S DAUGHTERS

FIGURE 11. Eunice Wakeman Burritt's name does not appear on a separate card, but by reference to her father's card (Figure 7) it is seen that she married twice. By her first husband, Jabez Cornwell, she had no children. Reference to the card of A. J. Sawyer shows that she had three children by her second marriage. The complications caused by carding only the male heads of families are greatest in the case of widows who marry a second time, but this is much less than would be caused by having separate cards for both male and female heads of families.

well, daughter of James Bidwell, that her paternal grandparents were John Hinsdale and Elizabeth Cole, daughter of Nathaniel Cole, also that she had two full sisters, Roxana and Ruth, and two half-sisters, Sarah and Ruth. If we wish to trace her paternal ancestry further we then turn to the card of John Hinsdale which will give us the names of his parents, and so on to the end of the series. We may lay these cards in a row and read off the Hinsdale ancestral line as far as it goes. If the Cole ancestry is of interest, turn to the card of Nathaniel Cole and in the same manner follow the Cole line. Elizabeth Hinsdale's mother's family will be found on the James Bidwell card. In this way we may trace any ancestral line that we will, passing with equal ease to male or female lines. The children on each card furnish the connection to all collateral lines.

For tracing descendants or collateral relationships we start with the lists of children on any card. Thus in Figure 7 we note that the eldest son of Elihu and Elizabeth (Hinsdale) Burritt married Ann W. Watson, daughter of John Watson, they had issue and the family is carded. Turning then to the card of Elijah Hinsdale Burritt, Figure 10, we find the record of his children so far as known. This card shows also that his son, George Hinsdale Burritt, married and had issue and the family has been

carded. The latter's card will then show the next generation and so on.

In the case of a daughter, since the system is only for male lines, we turn to the card for her consort. Thus in the case of the daughter, Eunice Wakeman Burritt, we learn from Figure 7 that she married twice, that she had no issue by her first marriage, but had children by the second marriage, and this family has been carded. To find her family we do not turn to a card for Eunice Wakeman Burritt, for there is none, but we turn to the card for her consort, A. J. Sawyer, Figure 11, where we find the known data of this family. Observe that the fact that Eunice was a widow does not appear on this card, only her maiden name and the name of her father is entered. The double marriage in her case is found when we look up her record on her father's card. It thus follows that where a woman has two or more families by different husbands, each family appears on a separate card under the name of the husband. The facts, however, are readily determined on turning to her father's card. The several families of a man all appear on one card. This necessarily comes from carding only male heads of families and though it seems to involve an inconvenience in the case of the remarriage of widows, this is not very serious. On the other hand, to attempt to card both males and females as heads of families, involves many complications and would necessitate a large amount of duplication.

It appears evident, from the above account, that so far as the records are entered upon these cards it is a simple matter to trace a person's relationships in all lines of ascendants or descendants or in the endless ramifications of collateral lines through every degree of consanguinity and even passing out into the diffuse and endless realm of connection by repeated affinity.

Arranging the Cards

In practical use the worker may find it possible to reduce the labor of filling out the cards by omitting much of the data provided for, but care should be taken not to omit any datum which may be needed to identify different individuals of the same name, and all names should be given, if possible, as these form the connecting links with other cards in the system. The writer has found that it pays to record all the data that can be obtained, even though it takes some patience to do it.

As is readily seen, each card is an independent unit representing a family group and its location in the collection has nothing to do with its connection to other family groups. For general purposes it is most convenient to keep the cards in a simple alphabetical order. It is, however, possible to arrange and rearrange the cards repeatedly in any combination that may especially suit the purposes or whims of the worker. This need involve no other labor than that of sorting the cards and the use of such guide tags as the special arrangement devised by the worker may require. In studying ancestry the cards may be arranged in the order of the ancestral line under consideration. For determining degrees of collateral relationship, the cards may be arranged in two series with reference to any common ancestor and then by simply counting the cards the degree of relationship is at once determined. Other combinations may be worked out according to the purposes of the investigator. If one wishes to keep track of localities for the purpose of local history studies, the locality where the family chiefly lived may be entered on the top line in the column of "Remarks." Such cards may then be easily detected and temporarily grouped by localities when so desired.

The great advantages of the system

are its flexibility, its expansibility, the ease of interpolation, the simplicity of the record, and the constant maintainance of the connection of every card with every other related card in the entire system. To keep it up requires attention and a large amount of clerical labor, but no more than any other system which may be of less efficiency.

A View of Birth Control

BIRTH CONTROL, by JOHN M. COOPER, Ph. D., Associate Professor of Sociology, Catholic University of America. Pp. 96. Published by the National Catholic Welfare Council, Washington, D. C. 1923.

The abundant controversial literature on birth control contains few contributions of more weight than this statement of the official Roman Catholic position, and the reasons that are held to justify this position. The Church's attitude, briefly, is that birth control is permissible in proper cases, but only through the practice of continence, the use of all artificial contraceptives being condemned. The grounds underlying this position are set forth by Dr. Cooper in a remarkably persuasive way, and the chief contentions of the birth-control propagandists are then assailed one by one and badly damaged. Dr. Cooper's task is, of course, facilitated by the fact that nearly all the birth control propaganda is composed mainly of fallacies and puerilities, and is based on emotion rather than on reason.

This is not to say that the reviewer accepts all of Dr. Cooper's premises, or all of his conclusions; or that other readers are likely to do so, unless they be Roman Catholics. But it must be frankly recognized that the author has met the birth control propagandists on their own ground and to a large extent beaten them. It is to be hoped that his attack will call forth replies that are of as high an order, in respect to logic and scholarship. The pseudo-scientific rhapsodies that have composed a large percentage of the "birth control literature" have been a glaring example of how a biological problem should not be debated.

The weak point of Dr. Cooper's position (and one which he does not at all attempt to evade) is the fact that he is arguing against a *fait accompli*: birth control is already here, and here to stay. Neither the authority of the Church, nor any other power, is likely to stop it. So far, no unprejudiced person doubts that it has done great harm to the race, eugenically; because it has been practiced more by the eugenically superior than by the eugenically inferior. There are two possible remedies for this serious situation: one, which the birth control propagandists have espoused, is to get the practice more widely spread among the inferior. This, for a variety of reasons, is a difficult if not hopeless task. The other is the constructive eugenic policy of getting such social and economic changes in effect as will prevent the superior from limiting the number of their births excessively. This, too, is difficult, but not hopeless.

Most biologists are convinced that the practice of birth control is desirable, within proper limits. But the question is still a very live one. No interested person can afford to overlook Dr. Cooper's concise and thought-provoking pamphlet.—*P. P.*

DEFECTIVE SEEDS IN MAIZE--AN ANCIENT CHARACTER

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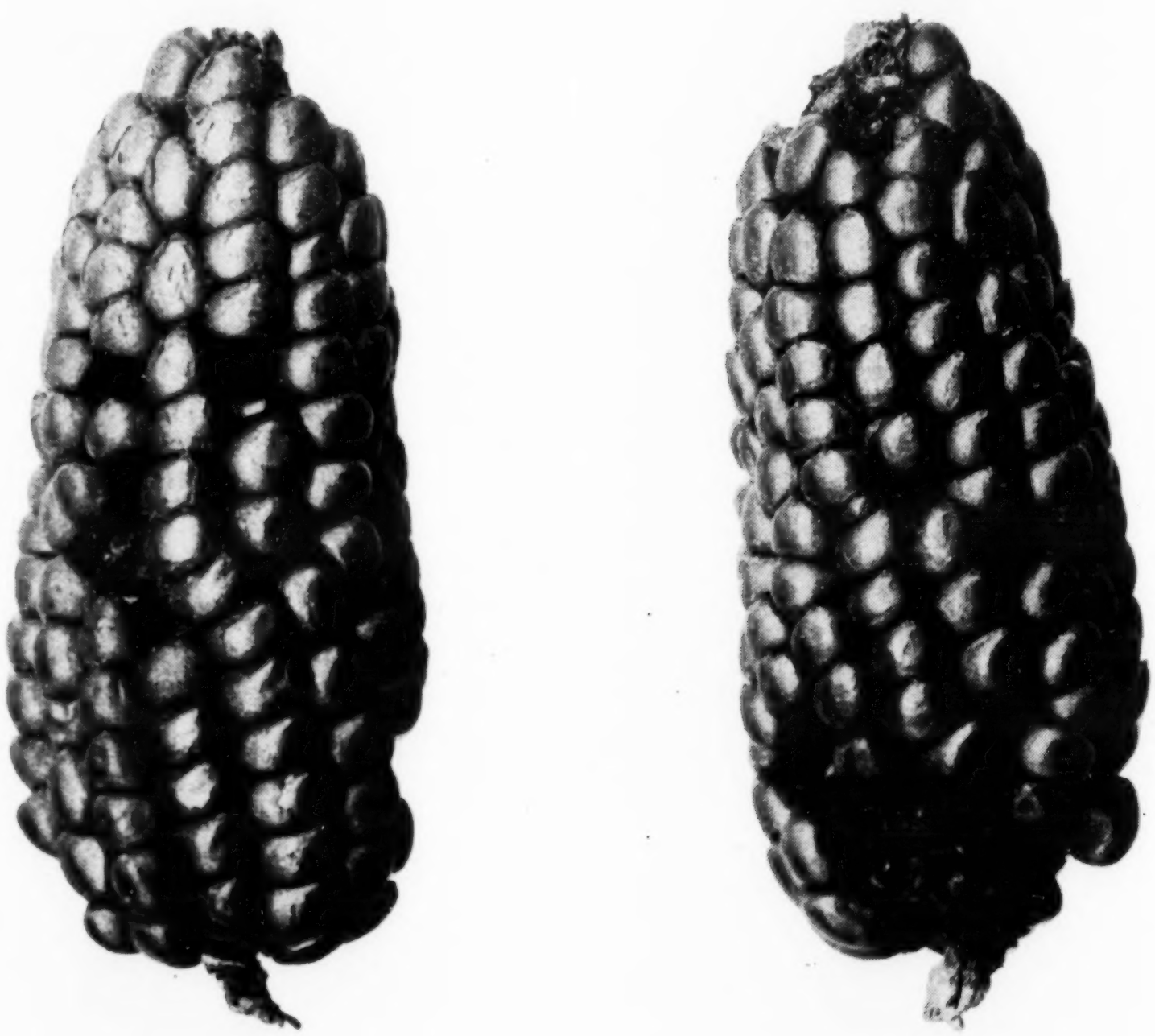

DEFECTIVE GRAINS AT LEAST THREE CENTURIES OLD

FIGURE 12. This ear of maize was unearthed in an Indian graveyard in Peru, unused since the time of the Spanish Conquest. The ear is, therefore, at least three hundred years old, and may be centuries older. One of the defective grains is shown in each view. Defects of the endosperm exactly similar in external appearance are found today in self-pollinated strains of maize, and it is interesting to speculate whether any of these modern abnormalities are genetically the same as this ancient defect.

THE ear of maize illustrated in Figure 12 was obtained from an Indian grave at Rontoy, Peru, on March 24, 1923, by Mr. D. S. Bullock of the Bureau of Agricultural Economics, who presented it to the Office of Cereal Investigations, Bureau of Plant Industry, on April 19, 1923.

The Indians were placed on reservations some distance from Rontoy at the time of the Spanish Conquest, and the burying-ground in which Mr. Bul-

lock obtained this ear has not been used since that time. The ear, therefore, is at least 300 years old and, of course, may be much older. It is not unlike ears of maize that have been received from time to time from various parts of South America, and is of some interest in this connection.

Defective seeds as a heritable character of maize were reported first by Jones.[1] More recently Lindstrom[2] and Mangelsdorf[3] have reported on other specific types of defective seeds, and many additional types are known. In fact, among the most common and apparent effects of self-pollinating maize for the first time are ears showing segregation for some type of defective seeds.

In view of these facts it seems of special interest that the Rontoy ear contains several defective seeds, one of which is shown in each of the illustrations. These seeds apparently are of the type that has been called "compressed" when it has occurred in the author's strains, although a disinclination to dissect the Rontoy ear has prevented a very close examination. On segregating ears these "compressed seeds" observed by the author, are evident only by their smaller size. Their classification is difficult because of intergrades due either to normal differences in kernel size, the complimentary action of genetic factors, or both of these causes. A study of the mode of their inheritance has not been attempted by the author beyond obtaining definite evidence that they are inherited.

Is the gene that was responsible for the defective seeds in the Rontoy ear the same as one of the many known to exist at present? Has it persisted individually in the germ-plasm throughout the countless generations since the Rontoy strain and our modern sorts were one? Or has it been eliminated by natural selection only to recur from time to time as a mutation? These and other questions are interesting bases for speculation, but, unfortunately lead nowhere. The fact remains, however, that maize grown by the Indians of Peru 300 or more years ago carried defective seeds entirely similar phenotypically to some of those found today whenever maize is self pollinated.

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The Changing Environment

A poll of sixth-grade pupils in St. Louis revealed that of 5,376 children questioned 40 per cent had never seen a sheep, and 17 per cent had never looked upon a pig. Of every hundred children, 12 had never seen a cow. It has been suggested that a cow and a pig be placed in the municipal zoo.

Dearborn Independent.

COMPLETE SEX-TRANSFORMATION IN THE DOMESTIC FOWL

F. A. E. Crew

Animal Breeding Research Department, Edinburgh University, Scotland

IN FEBRUARY, 1921, a Buff Orpington was brought to this Department. During the preceding January its owner had decided that there was far too much crowing for a city pen, and she had had the male bird killed. Shortly after this it was noticed that a great deal of crowing was still coming either from the pen or from somewhere nearby, and at length it was found that one of the hens was responsible for the noise. This bird was three and one-half years old, pure-bred, and had ceased to lay in the late summer of 1920. She had raised several broods of her own chickens. On her arrival here she exhibited the classical signs of early ovarian disease, the head-furnishings were larger than those of a typical hen of her breed, the left spur was three millimeters, the right one two millimeters in length. The plumage was entirely henny. She crowed persistently, but as one practising, and her sexual behavior was completely indifferent.

In April, 1921, the vascular tissue of the head had become markedly turgescent so that the eye appeared to be deepset amid flaming red congested flesh; and the comb, wattles and spurs had progressively increased in size. The bird had begun to moult irregularly, and was suffering from an intractible diarrhoea, losing weight and seeking solitude. By October she had become completely cocky-feathered, though she could never retain her tail sickles. The spurs were now one centimeter in length and the legs had assumed the red tinge which characterizes the male of her breed. She was carefully nursed through the winter and by February, 1922, she had overcome the more urgently dangerous symptoms, was crowing lustily with a challenging note, and was readily attracted by hens, which, would squat at her approach, the sexual act being performed. "He" fought with every male in the yard and was gently courteous to hens. In fact, only by one with an intimate knowledge of poultry, or by placing it alongside a "real" male, could it be told that this bird was different from a typical male. Its stance was different from that of a cock, for the bird was shorter on its legs and these were set at a different angle with the body.

On February third, the bird was penned with a virginal Buff Orpington far removed from all other birds. This hen was laying, and the eggs which she had laid during the previous fortnight were incubated and found to be unfertilized. Her mate performed the sexual act regularly and fluid passed into the cloaca of the hen was withdrawn and examined. On April 23rd a few living spermatozoa were identified. On June sixteenth the hen became broody and was set upon nine of her own eggs laid during the previous eighteen days. On July seventh two chickens were hatched; the other eggs were clear. By this time the father of these chickens had again become seriously ill and a large tumor could be felt cephaled to and discreet from the gizzard. The bird began to lose weight rapidly and suffered from serious diarrhoea. On December twenty-ninth "he" fell into an opened drain and was drowned. At the time of its death its comb measured four centimeters at its highest point, the right spur was four centimeters, the left five centimeters long, the scanty plumage was entirely cocky.

On dissection the liver was seen to be of great size, weighing 340 grammes, and studded with rounded areas of what proved to be caseating tuberculous material. The intestinal tract was also the seat of tubercular lesions. Lying in the situation of the ovary was a rounded mass, seven by four centimeters in size, with its purple surface mapped with raised yellow areas. This mass weighed 52.5 grammes, and incorporated in its dorsal aspect there was a body exactly resembling a testis whilst a similar body was situated in the equivalent position on the other side of the body. These testis-like bodies measured three and a half by two centimeters, and had even outlines and surfaces. The adrenals were larger and more prominent than is usual and there was nothing noteworthy about the thyroid or pituitary. On the left a thin straight oviduct could be traced, its diameter at its caudal widest part was three millimeters, and paired vasa deferentia were clearly discernable.

On sectioning, the tumor mass proved to be an ovary practically completely destroyed by tuberculosis; the testes-like bodies were seen to be testes in a phase of reduced activity. The seminiferous tubules were precisely similar to those of the testis of a normal cock, consisting of a well-defined basement membrane lined by seminal epithelium showing every stage of spermatogenesis. They differed from a very active testis in that they were smaller in size and showed fewer mitotic figures; ripe spermatozoa were present, but not in large numbers. The intertubular tissue, as in the case of a normal cock, was present in small amount and consisted of connective tissue only; no luteal cells were to be found. Only one Wolffian body was sectioned, it resembled an epididymis rather than a parovarium.

The bird described had been, up to the age of three and a half years, an unremarkable hen; she had laid many eggs and had raised many of her own offspring. Her history was intimately known, for her owner kept but few birds. In the autumn of 1920 she began to suffer from disease of the ovary; the ovarian tissue as progressively destroyed, and the effects of this pathological castration were seen. But the conditions which were created were those favorable for the differentiation and growth of spermatic tissue. New sex-cords developed from the germinal epithelium and spermatic tissue was differentiated both in the left gonad and also in the atrophic right. The bird became anatomically equipped to function as a male, for with the development of the testes the Wolffian ducts were stimuluated to form functional vasa deferentia and the cloacal apparatus of the male was developed. Synchronously with the replacement of ovarian by spermatic tissue the oviduct underwent atrophy. The bird functioned as a male and actually became the father of chickens. Under these circumstances, in which a "determined" female becomes a "somatic" male as a result of a definite change in its metabolism, it would be expected that the proportion of the sexes among its offspring would be one male to two females. Of the two chickens one is a male, the other a female; they have been mated, and their offspring are typical Buff Orpington chickens.

THE RACIAL PROSPECT IN SOUTH AFRICA[1]

THE future of the various races of South African natives can be foretold with much probability. The Bushmen and Koranas are rapidly passing away as distinct races, the remaining individuals being steadily absorbed by the other races, mainly by the mixed Hottentots, and in one hundred years it will be difficult to find a pure Bushman or Korana. The Hottentots will survive longer as a distinct race. In Namaqualand, where there will never be any very extensive white settlement, they may survive in a state of relative purity for some hundreds of years, and so also in Southwest Africa, but in other parts of South Africa they are bound to become absorbed into the mixed Cape Race or the Bantus.

But the future of the Bantus is very different and provides those of us who dwell in South Africa with our most alarming political problem. Almost all colored races of man go down before the onslaught of the white man's diseases and alcoholic drinks. The South Sea Islander, the Australian, the Bushman are all passing away, but the Bantus thrive, and today are multiplying twice as fast as the whites. Every Kafir wishes to have a family and generally marries young. Polygamy has been recognized from time immemorial and even Christian missions have to compound with it. Since devastating native wars have ceased under the *Pax Britannica*, the sexes have become more equalized, and polygamy is now the exception, but it is still largely practiced in the native territories. Every woman becomes the mother of children and many have large families. At present the Kafirs or Bantus outnumber the whites by about five to one, and every year the proportion of black to white is becoming larger. Before very many years it must be ten to one, and before the present century draws to a close it seems very certain that the Kafir will rule the whole of South Africa, and white civilization be replaced by black. There will be no need for the Kafirs to rise in rebellion in order to gain commanding power; they have only to breed and to study. The Kafir chiefs are often men of great intellect, and they are certainly better statesmen than many of the whites. They look far into the future. In the first half of the nineteenth century there was a continuous succession of Kafir wars, and the blacks showed that they must be classed as formidable warriors. But since the Zulu War in 1879 there has been no serious native war. There has, however, been far more serious native peace. When there was a little rising in Zululand about a dozen years ago and hundreds of Zulus were shot down by machine guns, the Zulu mothers quietly said, "We can breed sons quicker than you can shoot them down."

In olden times the Hottentots were the more or less docile slaves of the Dutch and French immigrants. They were intellectually and physically too inferior to the whites ever to be any source of direct danger. But unfortunately the very inferiority of the Hottentots has given rise to the idea in the minds of many of the white colonists that all colored races are inferior, and that there is really no danger from the Kafirs, and as a result the Kafirs have been encouraged to come into Cape Colony, most of which was really originally the country of the Hottentots and the Bushmen.

Already the Kafir has displaced the

[1] Reprinted from *Natural History*, May-June, 1923.

Hottentot as the laborer in most of the towns, on the railways, and on most of the farms of the middle of Cape Colony. He is also displacing the poorer class of whites and the less intellectual. In most countries the unskilled labor is performed by this class of whites, but here in South Africa the Kafirs can do it more cheaply than the whites, and can do it just as satisfactorily. Hence there is nothing for the poor white man to do. Already we have in South Africa tens of thousands of a class that has no counterpart in any other country in the world—the "poor whites"—not well enough equipped through intellect and education for the performance of skilled labor and with no unskilled labor for them to do. Every year sees the problem getting worse. The government tries to help by creating labor colonies, land settlements, and through other schemes, but for every thousand relieved, two thousand more seem to arise.

This class of "poor whites" with no steady work to do, and too often on the border of starvation, is a constant source of danger, being a ready tool in the hands of unscrupulous politicians. In 1914 there was quite a serious rebellion and this year again there was an attempted revolution in the Transvaal. Both these uprisings have been put down by the government, but the disease continues. Until recently the Kafir competed only in unskilled labor; now he is entering the fields of skilled labor, and very steadily but surely displacing more and more whites.

Many years ago Balfour said that South Africa had a terrible problem in the native question, and he added, "I do not envy the man who has to tackle it." Whether for good or for ill to the world the Bantu and Negro tribes are going to play a big part in the future. It is well we should study them.

ROBERT BROOM.

Early Civilization

MAN is one, civilizations are many. The superiority of our civilization over all previous ones is not indisputable. Civilization, like mankind, does not proceed unerringly in evolutionary progress without some weaknesses and degeneracies. It would seem that we need clearer notions of man and civilization, a concept of civilization which will embrace a great variety of separate yet similar phenomena, thus making apparent the homogeneity of all civilizations with reference to their principal constituent. Familiarity with early man and early civilization will help clarify our ideas, for "the early world presents an ideal field for the study of the achievements of man, for the extension of our understanding of cultural problems and our appreciation of the great range of civilization."

In this mood Dr. Goldenweiser would have us approach his volume, *Early Civilization*[1]. The book is an excellent analysis and compendium of the rudiments of anthropology. The style is that of the methodical lecturer. Each essay is a unit in itself but is not without constant reference and relation to the other members of the series.

The book is divided into three main parts, the simplest of which is the first, consisting of descriptions of five primitive test tribes, and the author's reflections on the phenomena outlined in the first five chapters. The second part is a comparative study of the various component factors of civilization and their relations, and another chapter of reflections. The third part ascends to psychic theory. Erudite critiques of theories of early mentality characterize this portion of the book, and the summary chapter concludes the work.

[1] Published by Alfred A. Knopf. New York. 1922. Price $3.50.

Throughout Dr. Goldenweiser is very zealous in his effects to correct erroneous but prevalent ideas, such as those regarding the sense equipment of the primitive, his capacity for sustained labor, his resistance to pain. The author's arguments for belief in the importance of diffusion, the independent origin of geometric and realistic patterns in primitive art, are tenable as well as his disbelief in the comparability of children's art and primitive art.

The author is not without the fault of traveling the by-paths instead of the highway to reach his destination. Dr. Goldenweiser's attack on the doctrine of "inheritance by magic" is justified, but his acquaintance with breeders, that is, scientific breeders, needs to be cultivated. Citing examples of latter-day supernaturalism he states, "We hear of children born during the French Revolution with the revolutionary emblem on their chests; or again, a mother, frightened by a frog, gives birth to a child with a birthmark resembling a frog. . . No more than Jacob could resist the temptation of interpreting by a mechanism such as the above the peculiar and varied coloration of his sheep, can the modern fencier (fancier?) overcome the suggestive influence of the many instances in his experience where an interpretation through pre-natal influence *may* be made, and he makes it forthwith."

On the whole, however, the book does not abound in infelicities of matter or expression. It fulfils its function as an introduction to anthropology. As such it is worth reading and readable, a book for both initiate and novice.

F. L.

The Status of Evolution

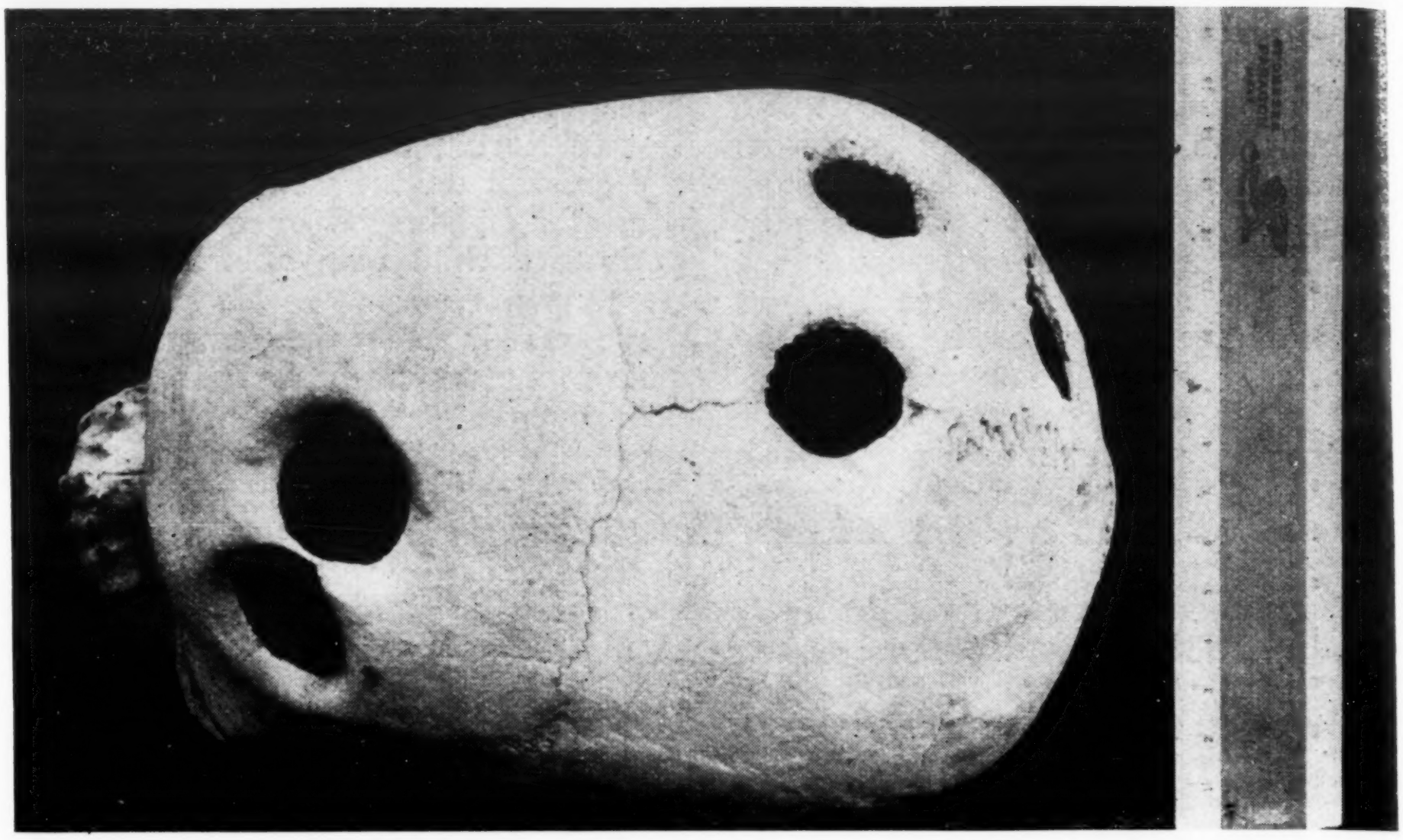
ALLEGEMEINE ABSTAMMUNGSLEHRE, by DR. BERNHARD DUERKEN, Professor at the University of Breslau. Pp. 205. With 38 text figures. $1.00. Berlin, Verlag von Gebrueder Borntraeger, 1923.

Professor Duerken's book is written for the much-exploited "general reader," and attempts to give a picture of the real status of the theory of evolution. He discusses the evidence in favor of evolution, taking up the conventional kinds—paleontology, embryology, comparative anatomy, etc.—and reaches the safe conclusion that there can be no real question as to the fact of evolution.

He then goes on to discuss current hypotheses regarding the method in which evolution has taken place. He groups these under the two heads of Darwinism and Lamarckism, and after an acute destructive criticism, on the ground of both logic and fact, concludes that neither of them is tenable. As to explanation of the mechanism of evolution, he remains what might be called an agnostic.

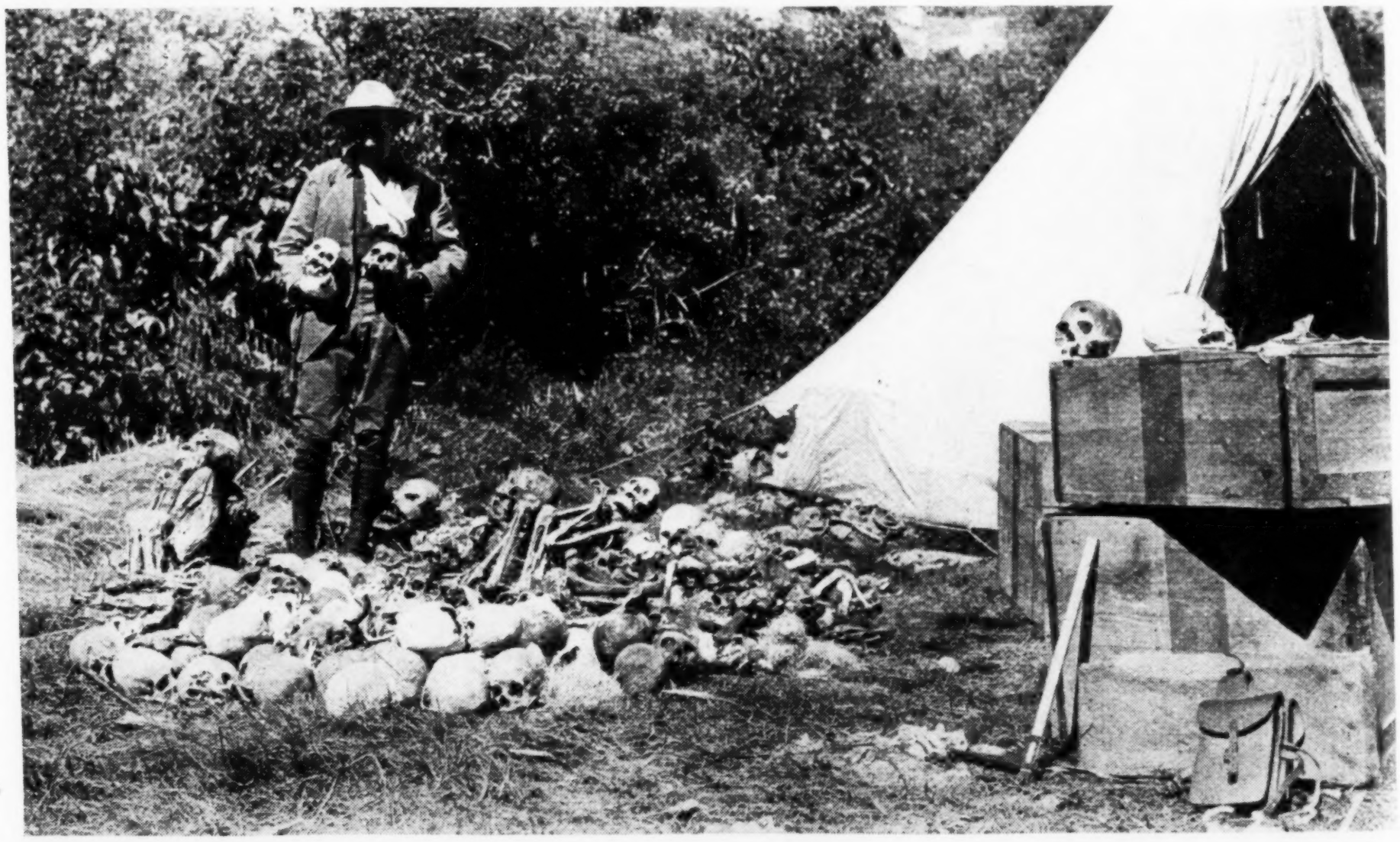
Every critical reader will find abundant matter for controversy in such a presentation. Nevertheless, the simply and clearly written book, with its insistence on clear thinking, might be read with profit by every student. It ought to serve an important purpose in the era which the author sees immediately ahead, when new developments in biology will finally bring the indisputable causes of evolution to light.

P. P.



THE FAVORITE OPERATION AMONG THE ANCIENT PERUVIANS

FIGURE 13. Naturally it is not possible to determine by an examination of skeletal remains whether the Incas indulged in the luxury of having their tonsils and appendices removed. Of all the surgical operations of which time has left us any record trephining the skull was by far the most popular in ancient Peru. The owner of this skull appears to have been the holder of the long-distance record for having holes cut in his skull. Not the least remarkable part of this operation was that the patient survived, at least long enough for the bone to show evidences of healing. (Photograph by courtesy of the National Geographic Society.)



RAW MATERIAL FOR THE ANTHROPOLOGIST

FIGURE 14. Some of the bones and mummies discovered by the Yale University-National Geographic Society Expedition in 1915, as they were removed from the burial caves. (Photograph by courtesy of the National Geographic Society.)

BONES OF THE ANCIENT PERUVIANS

A Review

THE July-September number of the *American Journal of Physical Anthropology* is devoted to a treatise on "Human Skeletal Remains from the Highlands of Peru," by George Grant McCurdy. The material was secured in 1914 and 1915 by the Peruvian Expedition of Yale University and the National Geographic Society, conducted by Professor Hiram Bingham, and was mostly from caves in the upper Urubamba Valley, the principal seat of the Inca civilization.

The ancient burials were largely in caves where the mummies were placed in a sitting posture wound with braided grass rope and supported by "seat-rings" of withes, twisted together and loosely wrapped with cords or strips of bark.

Of 341 crania examined, 147 showed the so-called "Aymara type" of deformation, "produced by circular constriction and compensatory elongation." Skulls of both sexes were deformed and a larger proportion of female skulls, sixty per cent, than of male, forty-three per cent. In cases of very pronounced deformation the foramen magnum may be reduced in size and the spinal cord constricted. Also the cranial capacity was found to be somewhat less in such skulls. Hence the conclusion is drawn that "excessive Aymara deformation has an inhibitory effect on the growth of the brain." It is easy to understand that the growth of the skull may be restricted by the tight-fitting woolen caps that the natives of the Peruvian highlands put on their babies' heads—and apparently leave on indefinitely.

By far the longest chapter is devoted to surgery, and relates mostly to the trephining of the skull, an operation which evidently was popular among the ancient Peruvians. Forty-seven trephined skulls were found in a series of 273 adults and in several cases more than one operation was performed, one of the skulls having five apertures. Of the forty-seven trephined skulls twenty-nine were recognized as males, sixteen as females and two as youths. Twenty-six cases were successful, and partial healing occurred in eleven other cases. The operations were chiefly on the left side of the head, which with other facts is taken to mean that the principal object was to relieve depressed fractures produced by star-shaped stone club-heads, which seem to have been the favorite weapon of the time.

That so many female skulls were trephined makes it seem questionable that the injuries were received in warfare. Did the women fight in war with the men, or was clubbing a neighborhood pastime?

Other injuries and abnormalities of the skull and other bones are also described in detail, including especially the teeth, which were often imperfect or diseased. There were no cases of supernumerary teeth, but milk teeth were often retained and caused irregularities in the permanent teeth. Pyorrhea, alveolar absesses, and other dental diseases were recognized in many cases. "In 12 jaws out of 422, the teeth had all disappeared prior to the decease of the individual."

No comparisons are made in relative frequency of the abnormalities or diseased conditions in other parts of the world. Though the colonizing policy of the Incas may be supposed to have resulted in a great deal of mixing of tribal stocks in some of the outlying regions, there probably was a general condition of inbreeding and congestion with resulting pressure upon the means

of subsistence. This is indicated by the very specialized systems of agriculture that were developed, as well as by the precautions that the Incas are reported to have taken against famines, which are confirmed by the discovery of many ancient storehouses. With the ancient precautions neglected, many districts that were terraced with stone-work, and no doubt were cultivated very intensely in ancient times, have been abandoned.

The Diseases of Children

SAEUGLINGSKRANKHEITEN, by DR. WALTER BIRK, Vorstand d. Univ.-Kinderklinik zu Tuebingen. 5. und 6. umgearbeitete Auflage, 10-17 Tausend. Pp. 282, with 26 illustrations. Price $1.40. Bonn, 1922, A. Marcus & E. Webers Verlag.

Dr. Birk presents a clear, comprehensive and well-organized discussion of the diseases of infancy in this volume, which forms part I of his "Leitfaden der Kinderheilkunde," a second volume being given over to "Kinderkrankheiten." He fully recognizes the importance of heredity in the varied problems which the pediatrist meets, although he does not go into this side of the case as fully as some might desire. Speaking of twins, he remarks that they have the most divergent constitutions, in spite of the identity of their surroundings. As to rickets, he declares that eighty per cent of the children in Germany are effected at one time or another, and that inborn predisposition plays an important part. The current theory that rickets is due to lack of vitamines he dismisses as not in accord with the clinical facts. He notes that the negroes in Africa are free from this disease, while it is extremely prevalent among the negroes of North America. The importance of rickets in forming the shape of the female pelvis is often not recognized until the girl becomes a mother. It is in this way of first-rate importance to eugenics. Dr. Birk closes with a brief review of the infant welfare movement. P. P.

Origin of Mongolian Idiocy

Mongolian idiocy is a typical form of amentia, taking its name from the fact that the children born with this condition often have a facial expressiin resembling that of the Mongolian race. Its cause is obscure, but has been set down by various writers as "uterine exhaustion," since the last child in large families seems to be more often affected than others. Statistics on the subject have been fragmentary, however. Available data have been reworked by Hornell Hart, who contributes a note to the *Journal of the American Statistical Association,* XVIII: 900-903, September, 1923. He finds that a Mongolian ament is twenty-three times as likely to be born to a mother forty years old or over, as to a mother between the ages of twenty and twenty-four. It is therefore clear that the condition is correlated with the mother's age; but the data are not sufficient to show whether the mother's age is significant because of a possible deterioration in the quality of the germ-plasm, or merely because the older mothers are likely to have had more children; or for some other reason.

THE TORTOISESHELL CAT

F. A. Hays

Massachusetts Agricultural College

GENETICISTS are almost universally agreed on the following points regarding color inheritance in cats:

1. That black males mated to yellow females give tortoise females and yellow males.
2. That yellow males mated to black females give tortoise females, an occasional black female, and all black males.
3. That black males mated to tortoise females give both tortoise and black females and both yellow and black males.
4. That yellow males mated to tortoise females give both yellow and tortoise females, an occasional black female, and both yellow and black males.

A few tortoise males have been recorded. Such males are considered sterile. The two most important questions in this connection are:

1. Why are tortoise males not of frequent occurrence?
2. Why are tortoise males sterile?

The first of these questions may be elucidated by a brief statement of the method of inheritance of the factors for black and yellow, which when together make the tortoise pattern. The results of the four types of matings enumerated above clearly place the two factors for coat color in the category of sex-linked factors as Little[2]* suggests. In such case the male progeny receive an X-chromosome from their dam carrying either the gene for black or yellow color. This chromosome is paired with the Y-chromosome from the sire. This assumed† Y-chromosome is apparently devoid of genes for the colors in questions so that the sons inherit their color only from their dams. Daughters receive an X-chromosome from both sire and dam and thus provide a mechanism for both the black and the yellow factor to occur in the female zygotes. The combined action of these factors gives the tortoise pattern.

Different concepts of the possible explanation for the occurrence of a few tortoise males need not be discussed. The sterility in such males has been explained by some as being due to imperfect sex development or to the partial transposition of the female to the male sex. Careful examination of the fetuses of seventy pregnant cats by Doncaster and Bember[1] has not revealed a single case of confluence of blood vessels or fused chorions.

A means of explaining the infrequent occurrence of tortoise males and their sterility, as well as the appearance of the few unexpected black females in crosses 2 and 4, exists in the crossing-over phenomenon. We may assume that a cross-over only infrequently occurs between the X- and Y-chromosomes of a yellow male because the genes occupy loci in very close proximity, and moreover that cross-overs sometimes take place in the two X-chromosomes of females. If a male with crossing-over between

* For numbered references, see *Literature Cited* at end of article.

† DeWinivarter has apparently discovered two types of spermatocytes in the cat, one carrying seventeen and the other eighteen chromosomes. He was, however, unable to trace the chromosomes farther than the spermatocyte stage. Because of the behavior of the colors black and yellow in inheritance, we may be justified in assuming the existence of the Y chromosome in half the spermatozoa until its absence is proven.

the X- and Y-chromosomes is mated to black females he should sire some tortoise males.

Spermatogenesis in tortoise males is not normal according to Cutler and Doncaster.[2] This may be due to the abnormal character of their Y-chromosome, since the Y-chromosome has been thought not to be the carrier of character genes until the discovery of "male-linked" by J. Schmidt[4] in fishes.

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THE CAUSES OF TWINNING

A Review

HEREDITY is a new standpoint in biology, reached through more intensive and constructive interest in the processes of reproduction. Though much more attention has been given in recent years to the study of the transmission of characters, there is an equal or greater need of understanding how the characters are brought into expression in the development of new individuals. Greater interest may be claimed for the expression relations because they are influenced by the environment, while transmission is independent of the environment. Probably on account of so much debate on the question whether environmental influences are entirely excluded from transmission, the need of more definite knowledge of the relations of environment to expression is commonly overlooked among students of heredity.

Thus it happens that a book which does not profess to treat of heredity, and even omits the word from its index, is nevertheless to be considered as an important contribution to the subject. The book in question is Professor Newman's "The Physiology of Twinning," a volume of the Science Series of the University of Chicago.[1] The writing and printing are well done, the treatment is not over-technical, and the reader is assisted by about seventy illustrations very skilfully drawn by Mr. Kenji Toda. The general interest of the book might not be suspected from the limited subject, but the treatment leaves no doubt that twinning is an important "lead" toward a better understanding of some of the fundamental problems of reproduction.

Development of two or more embryos from one egg is considered as the only genuine twinning, and this phenomenon is traced through all of the principal groups of animals, with special consideration, of course, for the armadillos. With these animals twinning is a regular occurrence and is supposed to be connected with a delay of development at the period of gastrulation, which Professor Newman considers as a general cause of twinning, and subject to environmental influence. The process of twinning is conceived fundamentally as a form of fission, analogous with dichotomous branching of plants. Fasciation is

[1] The Physiology of Twinning, by Horatio Hackett Newman, Professor of Zoology, University of Chicago. Pp. 230, xii. Price $1.75. The University of Chicago Press. 1923.

another plant phenomenon that might be compared with twinning in animals.

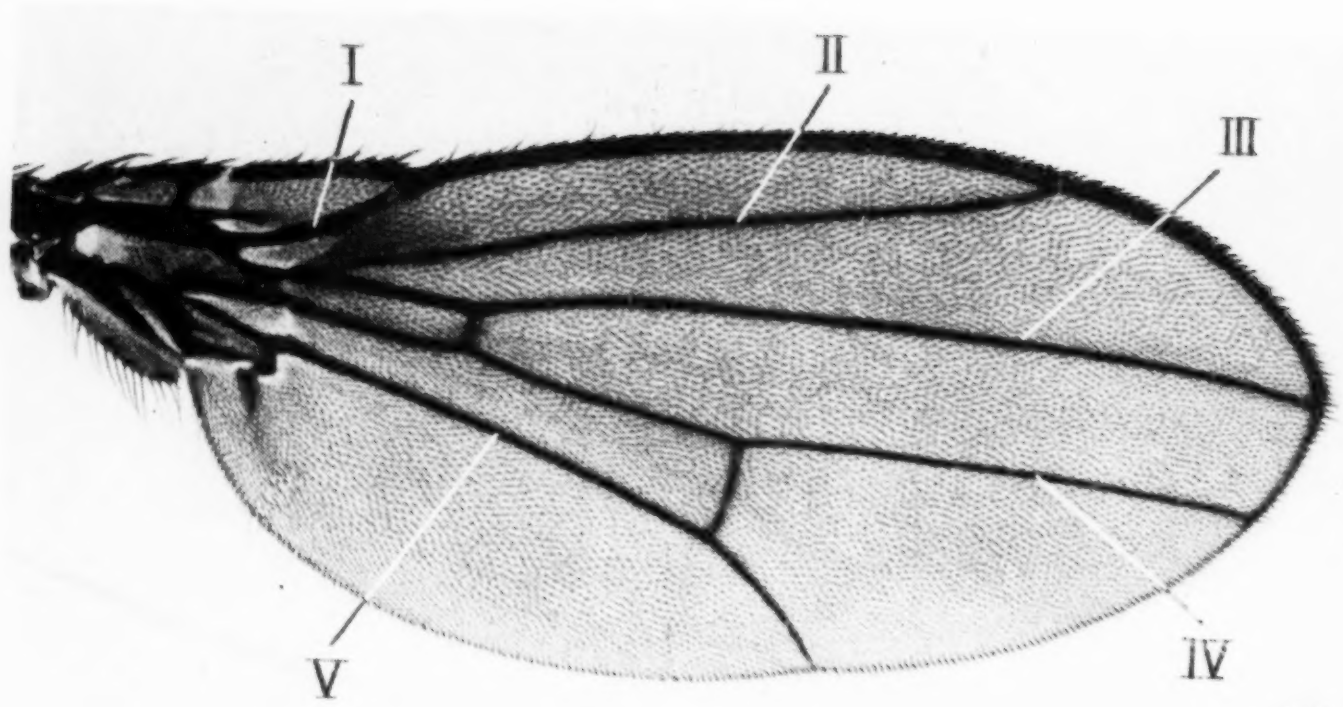
Intensive study of twinning would seem justified by the recognized interest of human twins as our most familiar evidence of the power of heredity to determine all of the characters in advance of development. The facts show that twinning is not a simple phenomenon, or merely an extra division of the fertilized egg cell, but involves a change of developmental behavior in groups of cells. The groups not only subdivide and separate but regenerate. The program of development is reorganized in relation to new median lines or planes of symmetry, so that two individuals are developed. As a result of twinning, cells from the median parts of the undivided group must become lateral, or regenerate lateral cells.

Totipotence, or genetic equality of the embryonic cells has, of course, to be assumed to account for the fact that the developmental functions of many of the cells are changed to accord with the revised plan of producing two individuals instead of one. The recognition of totipotence is an admission of the fact that the courses of development can be changed, but totipotence alone does not account for changing the plan, or for the assignment of the new and highly coordinated parts that the cells must play in the drama of development. Characters are expressed in all of the stages of development, in the sequence that is proper to the successive stages. Definite differences may appear in juvenile or embryonic stages, as well as in the adult stage if expression is varied or abnormal.

Though the characters of the adult are determined by the behavior of the cells in development, yet the cell behavior itself apparently is determined by a form of control which has the power to regenerate and reorganize, which amounts to redetermining the expression of the characters. No idea of such a directing or determining agency is afforded by current conceptions of heredity as a complex of independent Mendelizing "characters." The evidence that such changes of development as are involved in twinning can be initiated or induced by environmental causes, while the same plan or pattern of development is carried out with such exactness as twins often show, should be of interest to every student of heredity.

For some purposes twinning may be considered as a very slight form of abnormality, though connected by scarcely perceptible degrees with many more definite abnormalities. The forms of control and the nature of the adjustments that are required for the processes of normal heredity are shown most effectively in contrast with defects or disturbances of the normal course of development. The ability to resist adverse conditions of the environment and maintain a normal course of development is an important "character," or aspect of heredity. The best reason for the study of abnormal forms is to gain a better understanding of normal heredity. Monstrosities and malformations have been recorded extensively, but little use can be made of such facts for purposes of instruction until they are somewhat organized and interpreted, as many are in the present work.

O. F. Cook.



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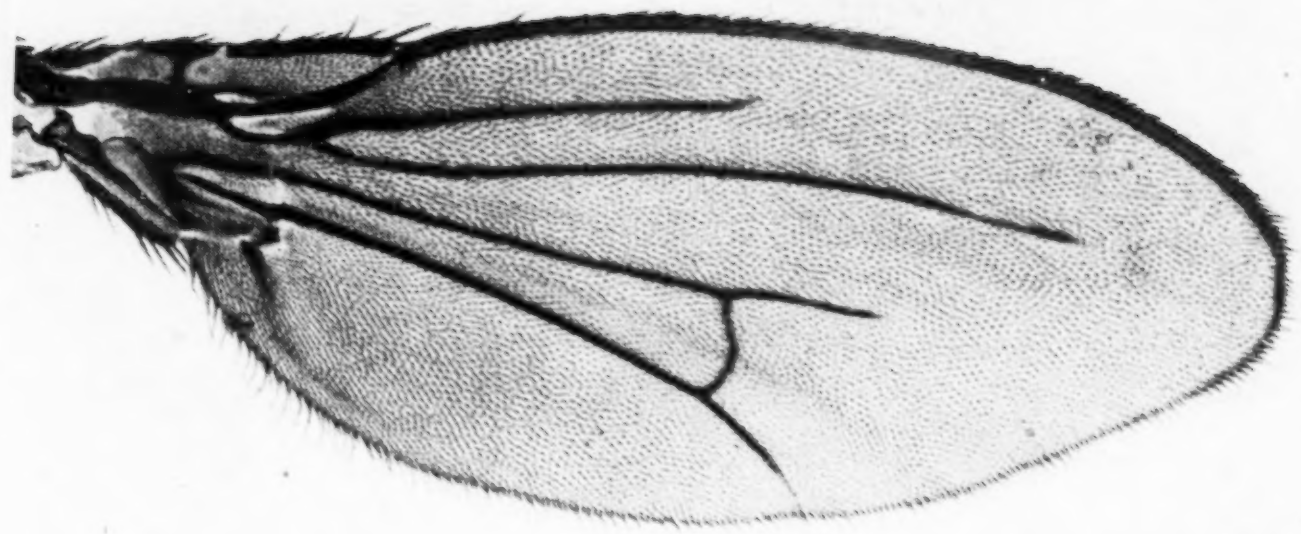

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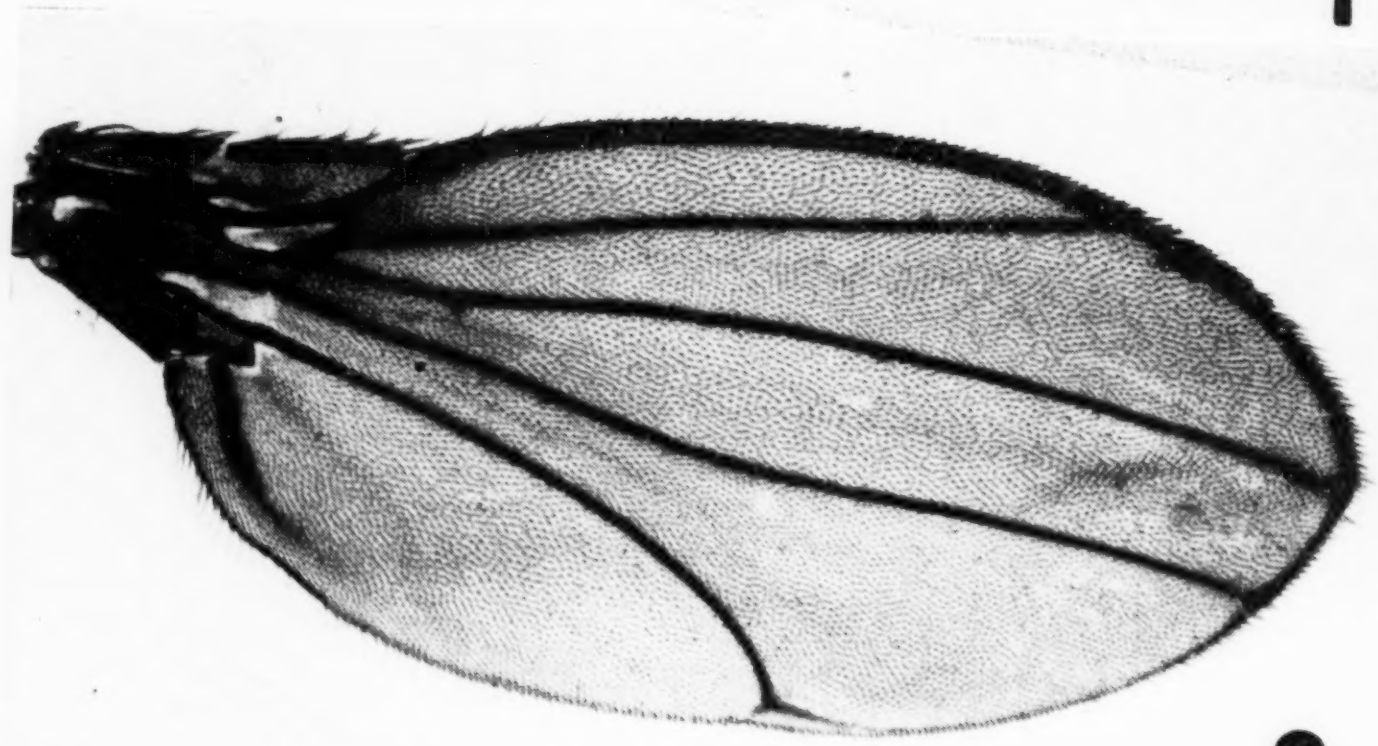

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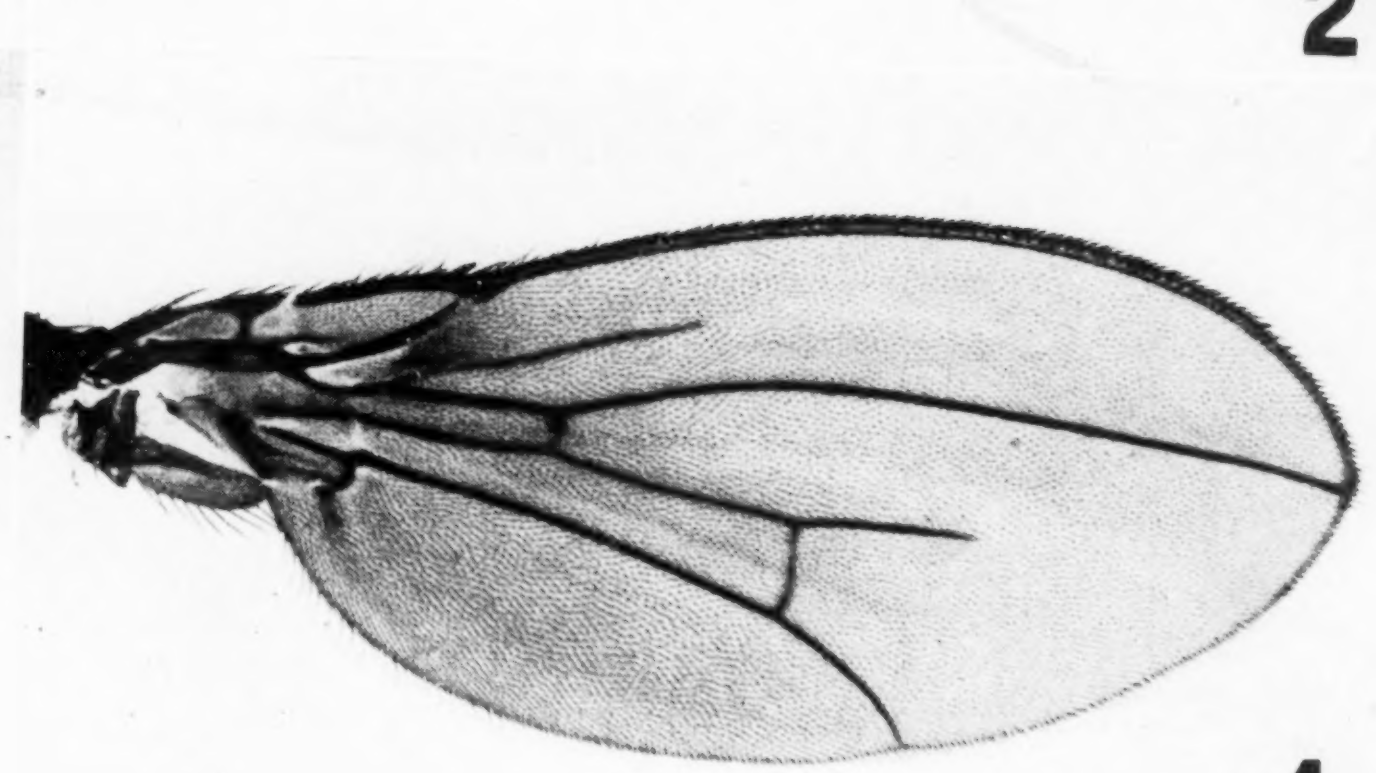

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NORMAL WINGS AND WINGS OF THREE SEX LINKED MUTATIONS

FIGURE 15. Number 1 shows the normal form of the wing in *Drosophila willistoni*. The five longitudinal veins are numbered for convenience in comparison. Number 2 shows the form of the wing in the mutant race called *abbreviated*, in which three of the veins do not reach the margin of the wing. The *crossveinless* mutant is shown in Number 3. Notice the branched ending of the fifth vein—characteristic of this form. Two distinct abnormalities are shown in Number 4: *interrupted*, involving the loss of part of the fourth vein at or near the apex; and *stump*, which affects the second vein in much the same way, although more of the vein is lost.

ADDITIONAL MUTANT CHARACTERS IN DROSOPHILA WILLISTONI

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TWENTY-EIGHT of the sex-linked characters in *Drosophila Willistoni*, Sturt., have been described in an earlier paper by Lancefield and Metz.[5]* The present paper includes descriptions of six additional sex-linked characters and twenty-three autosomal characters in this species. Accompanying each description is an account of the origin of the character and a comparison with similar characters in other species, wherever such characters are known. The linkage data, and a comparison of the genetic behavior of the characters with that of characters in other species, will be considered in a subsequent paper.

A list of the characters together with a brief statement as to their origin and nature are given in Table I. In this table the characters are arranged chronologically. In the subsequent descriptions the arrangement is chronological within the respective linkage groups, and in the section on characters not yet "placed."

The present mutant characters as well as those previously described have all arisen in a single line of flies derived originally from Cuba. Since the species does not occur in the United States, save rarely in Florida or adjacent regions, it is practically certain that no contamination of the stocks from outside sources has occurred.†

We are indebted to Miss E. M. Wallace for making the drawing of tardigrade, and to Miss E. M. Lord for assistance in making the accompanying photographs, and also for the other drawings.

Sex-Linked Characters

Interrupted (i)

Figure 15, No. 4

Description.—Interrupted is a variable character distinguished by a break in the fourth vein of the wing, involving the loss of a small section at or near the apex. The character is partially sex-limited, appearing fairly regularly in the females, but only occasionally in the males.

Origin.—(W1214). One male was found in a mating for short.

Bald (bd).

Figure 19

Description.—The bristles and hairs on the head are either very small, or entirely missing, in bald. One or all of the dorso-central bristles may be missing and the hairs on the thorax are more sparse than usual and the rows are irregular. Sometimes one, or both, of the anterior scutellar bristles may be small or missing entirely. The most constant characteristic of bald is its effect on the head bristles and hairs.

Origin.—(R789). One male was found in rounded stock.

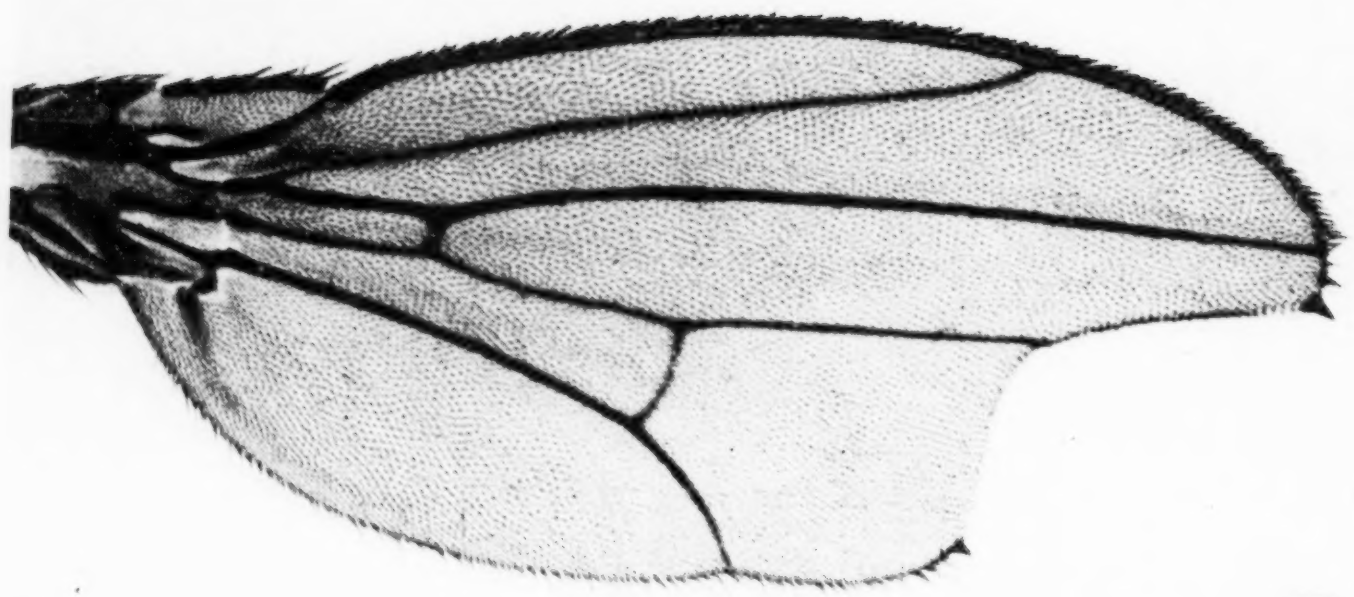
Vermilion (v).

Description.—Vermilion affects the color of the eyes, causing them to be a lighter and brighter red than usual. The black fleck in the center of the eye, characteristic of the normal condition, is missing in vermilion, and the ocelli are white rather than yellow.

Origin.—(R1074). One male was found among the offspring of a mating of blunt approximated by blistered.

*For Numbered References, see "Literature Cited" at end of article.

†Particular mention is made of this fact, only because the opinion is still held in some quarters (cf. Hagedoorn and Hagedoorn '22)[5] that *Drosophila* "mutants" may merely be segregates resulting from hybridization.



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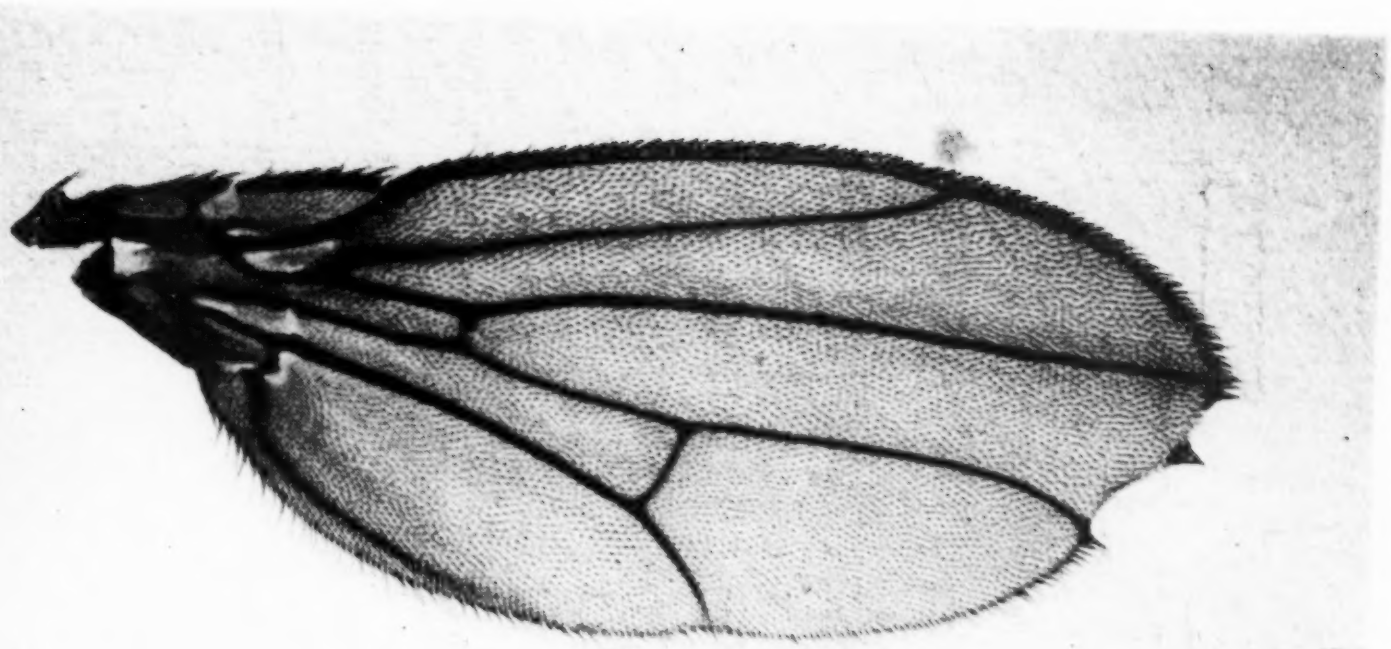

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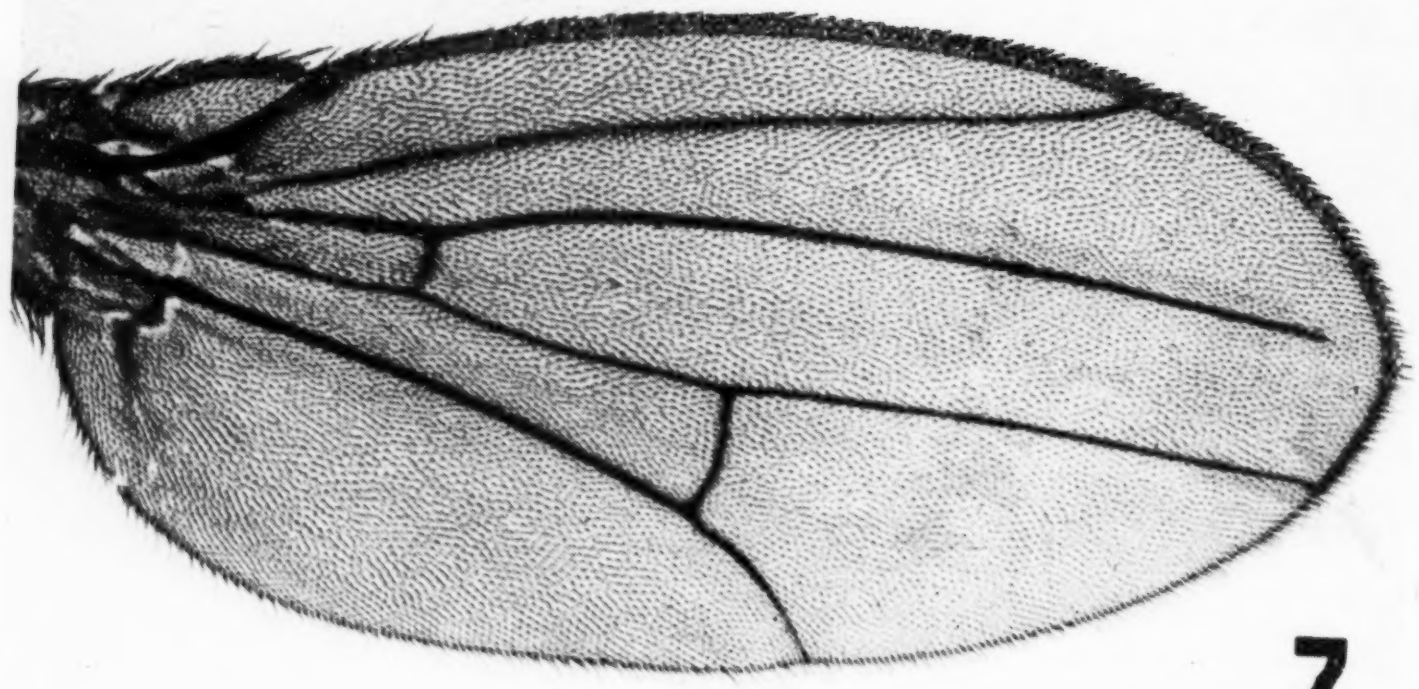

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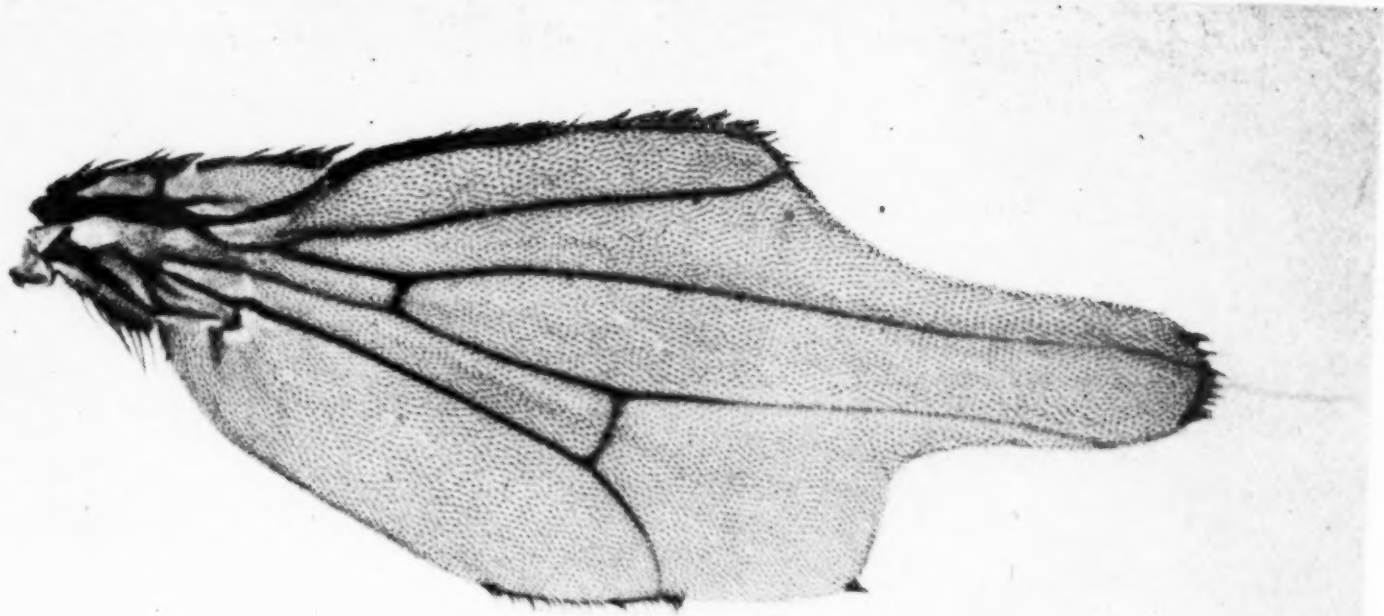

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FOUR MUTANT WING CHARACTERS

FIGURE 16. *Clipped* (No. 5) and *Scalloped* (No. 6) are quite similar, and may be due to the same gene. They are both dominant characters. In *broken* (No. 7) the second, third and fourth veins, or any combination of these, fail to meet the margin of the wing. *Ragged* (No. 8) is characterized by a wing with an irregularly cut margin on each side of the tip. The marginal hairs of the remainder of the wing are disposed in bunches. The genes for *Clipped*, *Scalloped* and *ragged* are located in the second linkage group. *Broken* is a sex-linked character.

Comparison. — Vermilion resembles the character of the same name in *Drosophila melanogaster,*[9] *D. virilis,*[5] *D. obscura,*[4] and *D. hydei.*[3]

Abbreviated (ab).

Figure 15, No. 2

Description.—In abbreviated, the second, third, and fourth longitudinal veins fail to reach the margin of the wing, the second and the fourth being affected the most. Usually the anterior cross-vein is missing though this is not a constant characteristic. Occasionally one of the scutellar bristles is bent at right angles to the scutellum. The wing itself is more pointed and narrower than the normal wing.

Origin.—(R1453). Fixty-six males were found in the first hybrid generation of a mating of rough scalloped by blunt approximated.

Broken (bk).

Figure 16, No. 7

Description.—In broken, the second, third, or fourth veins, or any combination of these, fail to meet the margin. Pure stock has not yet been obtained, hence it is not certain that the character always manifests itself.

Origin.—(R1532). Seven yellow scute rough stump broken females were found in the second generation from a mating of vermilion by yellow scute rough stump.

Crossveinless (c).

Figure 15, No. 3

Description.—Crossveinless is characterized by the absence of the posterior cross-vein and usually of the anterior cross-vein also. A small part of the anterior cross-vein may be present as far as the sense organ. The fifth vein enlarges as it meets the margin of the wing like a delta. There is also a slight enlargement of the other longitudinal veins as they meet the marginal vein.

Origin.—(R1627). Several males were found in ragged stock.

Comparison.—Crossveinless resembles the crossveinless of *D. virilis*[11] and *D. melanogaster,*[1] except for the apical enlargement of the veins. The latter feature is sometimes seen in our stock of crossveinless in *D. virilis,* but not commonly.

Second Chromosome Characters

Approximated (a).

Figure 17, No. 10, and Figure 21

Description.—In approximated flies the two cross-veins of the wings are much closer together than in the wild-type flies. The legs are also greatly modified, the first tarsal joint of each leg being absent and the remaining ones shortened.

Origin.—(L88). About twenty males and females were found in a normal mass culture.

Comparison.—The wing modification involved in this character is seen in mutants of other species, but not, so far as we know, in company with the leg modifications found here.

Spread (sp).

Description.—In spread the wings are held at an angle of almost ninety degrees from the body and are curved down. In older flies, the wing is usually curled or torn along the margin and the tip is often gathered in.

Origin.—(W18, W19). Two males and one female were found in a mating for sparse.

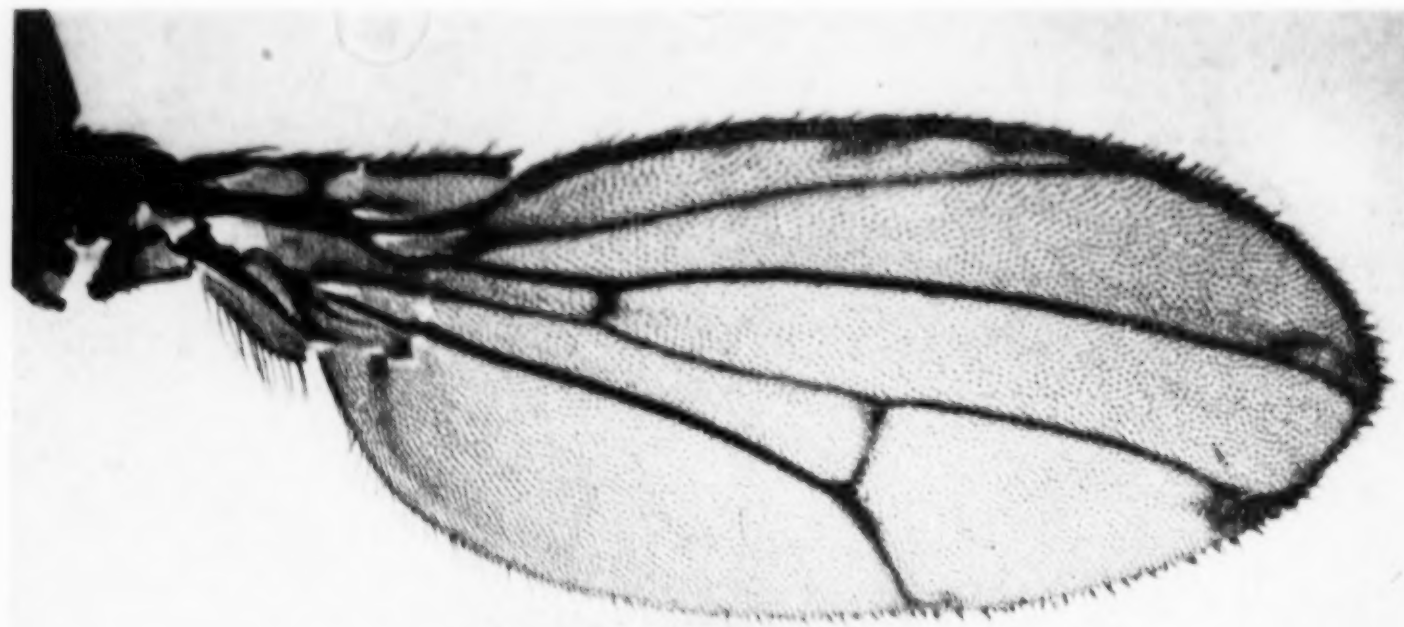
Comparison.—Spread resembles in a general way the numerous spread wing mutant characters of other species of *Drosophila,* but so far as we know none of the latter agrees with it in detail.

Blunt (b).

Figure 19

Description.—The scutellum is square instead of pointed in blunt. Usually one or both of the anterior scutellar bristles are missing, though all four scutellar bristles may be present, in which case the posterior ones are very much closer to the anterior ones than in the normal condition.

Origin.—(W13, W17). Blunt was found in the second generation of a mating involving approximated.



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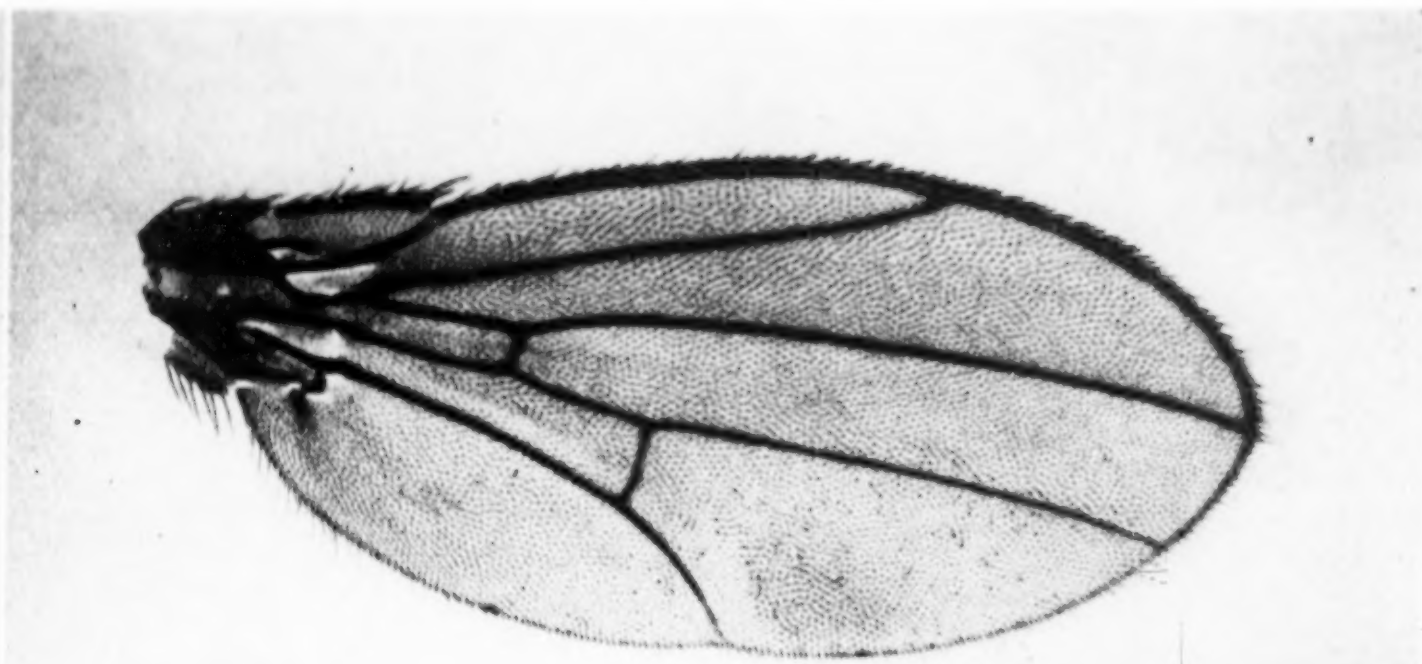

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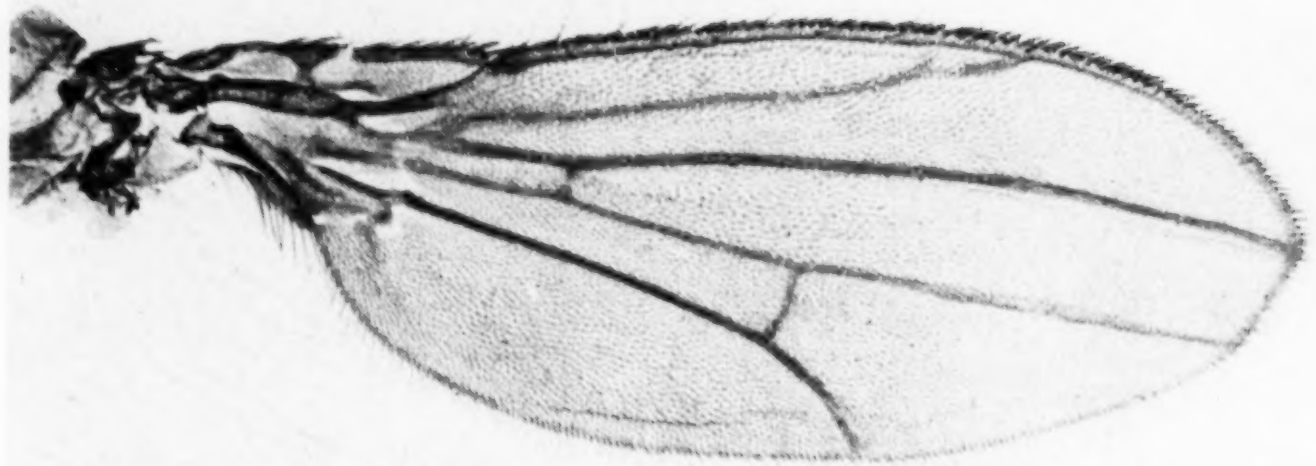

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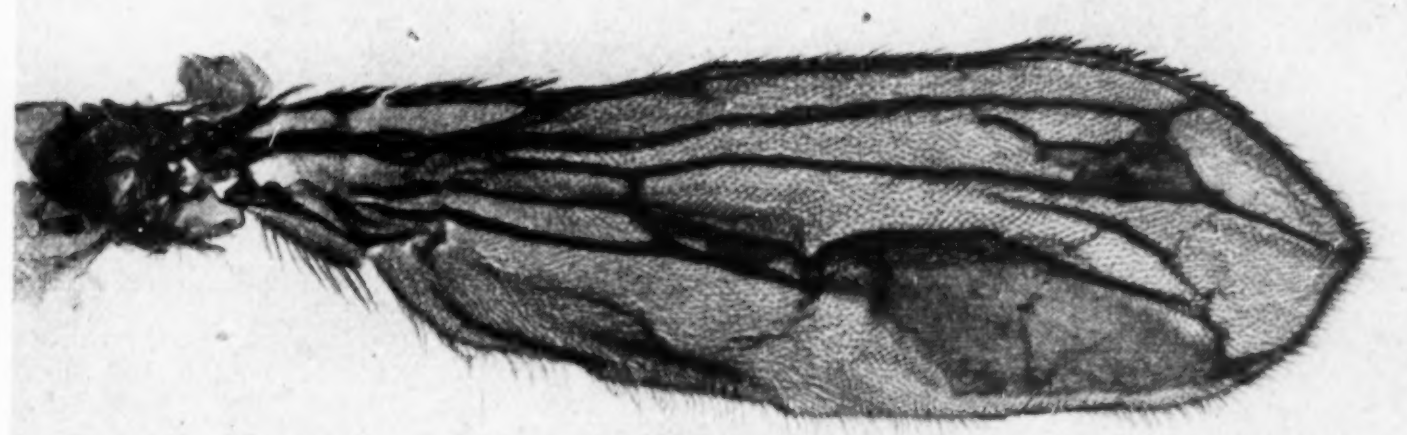

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FOUR INHERITED ABNORMALITIES

FIGURE 17. In *Knotted* (No. 9) the veins are enlarged irregularly, especially where two of them join. The marginal hairs are in bunches; the tip of the wing may be cut off squarely, or it may be bent up. The character is a dominant and the flies have poor viability. The two cross-veins are much closer together in *approximated* (No. 10) than in the normal form, and the legs are greatly modified (see Figure 21). The wings of *granulated* (No. 11) are shiny but with blotchy coloring. The veins are thickened and some of the bristles on the body are affected. *In balloon* (No. 12) there is a network of extra veins between the second and third, and between the fourth and fifth veins. There is generally a broken bubble between the fourth and fifth veins.

Circular (cr).

Description.—The wings are circular, and often balloon shaped; and the entire fly is small. As it had very poor viability, it was difficult to breed and the stock has been lost.

Origin.—(W294). Several males and females were obtained from a mating for sex-ratio.

Knotted (K).

Figure 17, No. 9

Description.—Knotted affects all the veins of the wings. They are enlarged irregularly into knots, especially where they meet each other or meet the marginal vein. There may be extra veins present as branches from the main veins, and the cross-veins may be gone or may be close together, like approximated. The marginal hairs are present in clumps giving the edge of the wing a fringed appearance. The wing is sometimes cut off square at the tip or it may be turned up at the tip instead of lying down over the abdomen as the normal wing does. The wings also are often smaller than normal. The character is a dominant and the flies have poor viability.

Origin.—(W922, L581). One knotted male and one knotted female were found in the first generation of a mating of rough rosette by morula.

Comparison.—Knotted resembles delta in *D. simulans*[10] in having the first vein thickened; the second vein frequently thickened at the end, and sometimes throughout the whole vein; and the others sometimes thickened. Like delta it is an autosomal dominant, and the flies have poor viability. Knotted differs from delta in not having a branch on the posterior cross-vein; in not having the wing-margin cut or nicked; in not having sterile females; and in having normal bristles on the scutellum.

Clipped and Scalloped (Cl and Sl).

Figure 16, Nos. 5 and 6

Description of Clipped.—Clipped is a dominant character, distinguished by variable incisions on the inner margin of the wing as shown in Figure 16. Presumably the gene is lethal when in the homozygous condition, for matings of clipped by clipped give approximately a 2:1 ratio, and selection (in keeping stock) for forty-four generations has failed to give a homozygous stock.

Origin of Clipped.—(W1828). Many males and females were found in a mating of rough by scute short-3.

Description of Scalloped.—The character scalloped agrees in all respects with clipped and is probably due to the same gene (or an allelomorph), although this assumption has not yet been tested adequately.

Origin of Scalloped.—(W1854). Many males and females were found in a mating of rough by scute short-3.

Apterous (ap).

Description.—Apterous is characterized by the entire absence of wings, by greatly reduced balancers, by the square rather than pointed scutellum, and by the absence of scutellar bristles (in most cases). In addition, the thorax is sometimes greatly deformed. Since both sexes are sterile the character is very difficult to keep in stock.

Origin.—(R64). Several females were found in the rough clipped stock. Later a few were found in the rough scalloped stock.

Comparison.—Apterous flies have been found in other species of *Drosophila* (e. g., *D. melanogaster*[7]) but the difficulties of breeding have made detailed linkage studies impracticable, and comparisons may be omitted here.

Ragged (rg).

Figure 16, No. 8

Description.—The margin of the wing is cut irregularly on each side of the tip and the marginal hairs are present in clumps along the part of the edge which has not been cut.

Origin.—(R1155). Several males and females were found in a heterozygous stock carrying combined.

Red (red)

Description.—Red is an eye color character. The eye is a darker and

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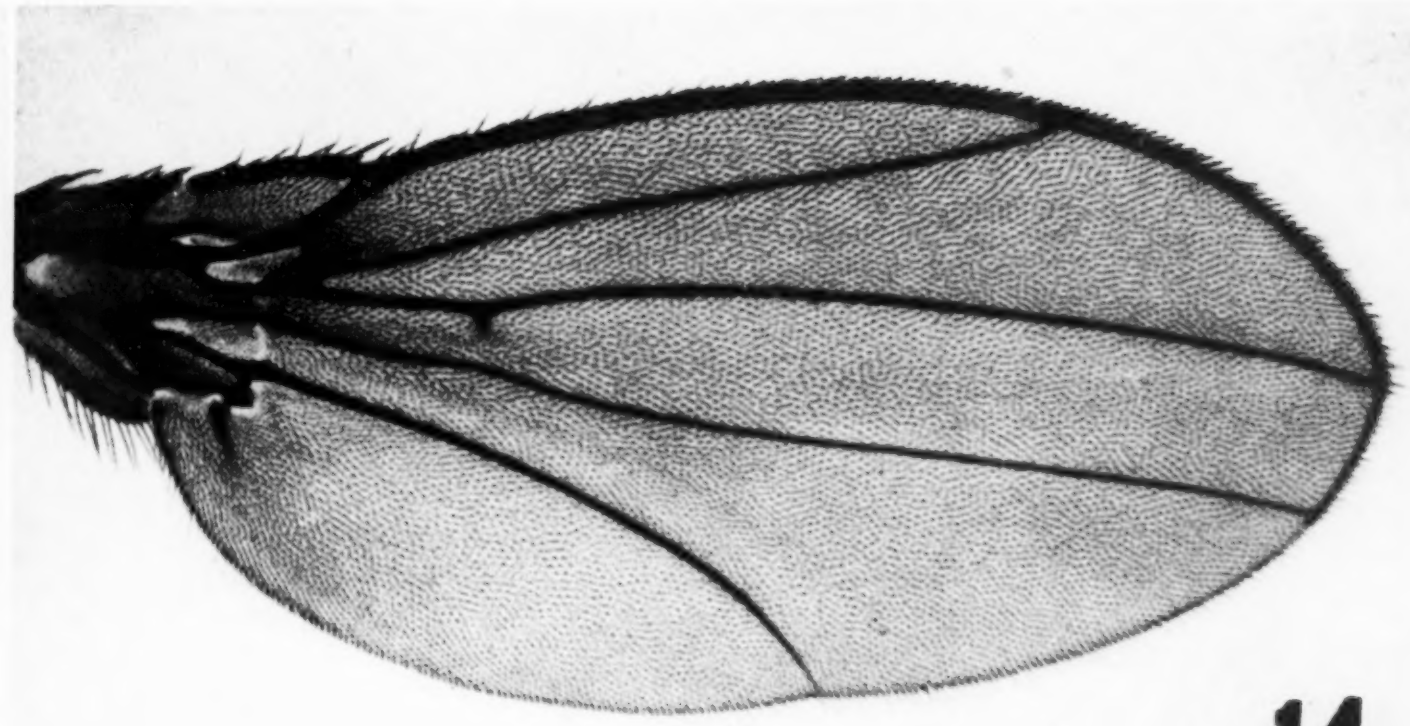

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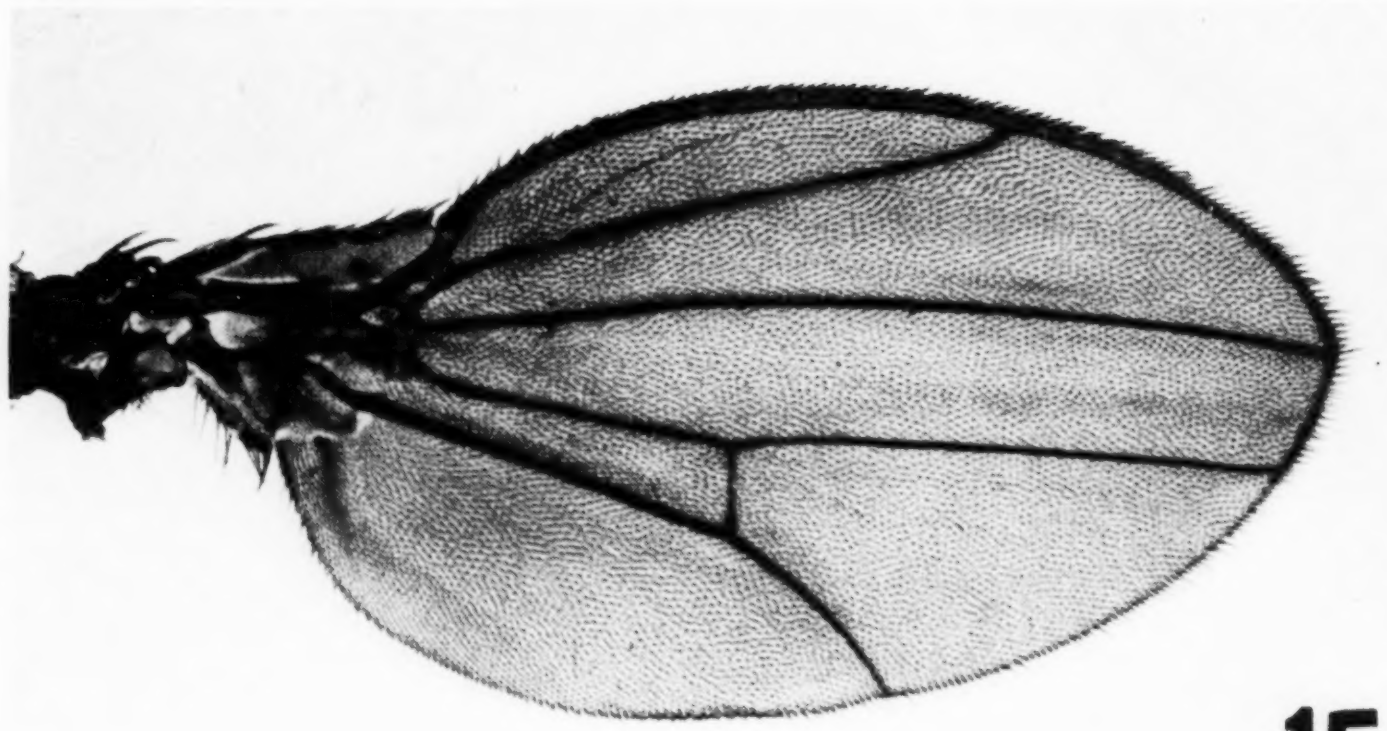

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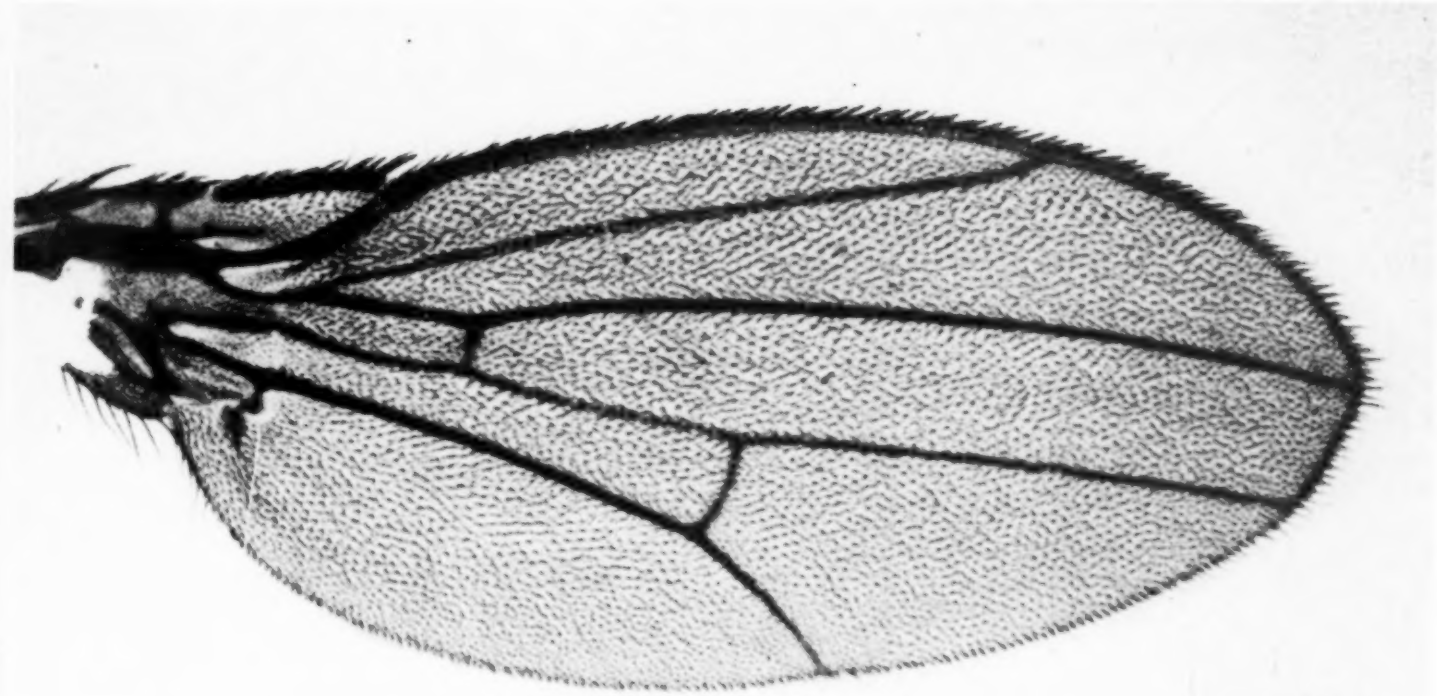

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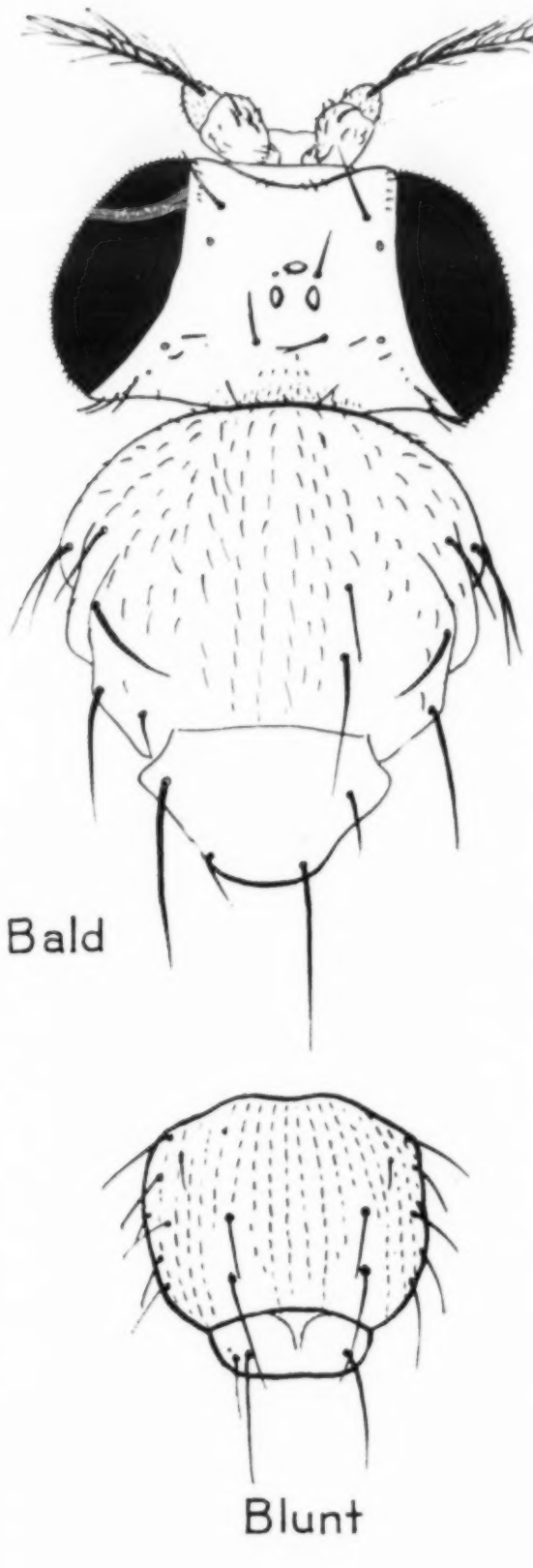
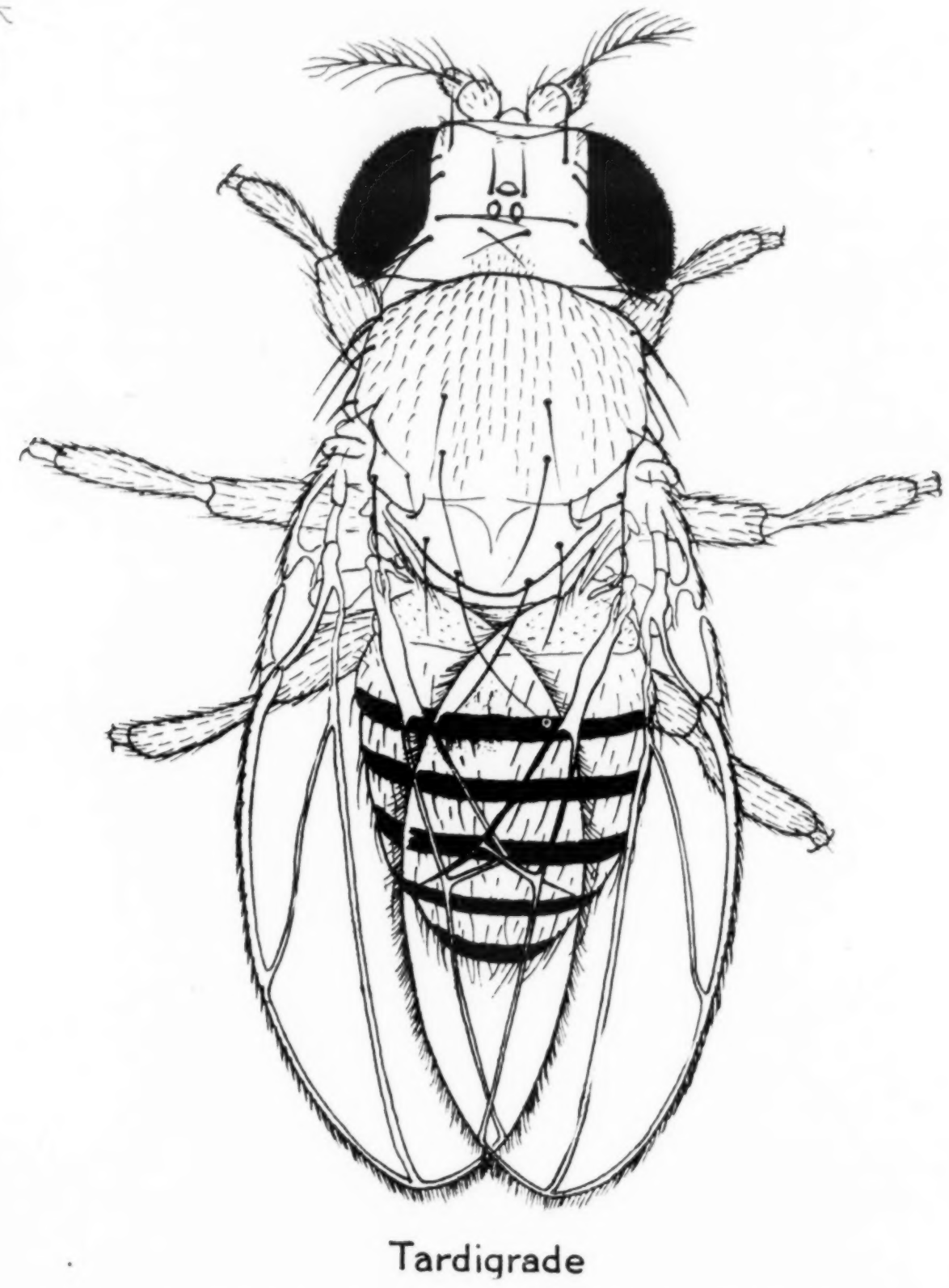
CHARACTERS IN THE THIRD LINKAGE GROUP

FIGURE 18. In the mutant race called *absent* (No. 13) both cross veins may be missing, or only the posterior one, as shown here. *Incomplete* (No. 14) resembles *crossveinless* (Figure 1), but this is an autosomal character (not located in the sex-chromosome) while *crossveinless* is a sex-linked character. In *rounded* (No. 15), the wing is shorter and broader than usual, and one or both cross veins may be lacking. *Blistered* (No. 16) affects eyes and bristles as well as the wings. The hairs on the surface of the wing are arranged irregularly, giving it a roughened appearance.





MUTANT CHARACTERS OF HEAD, SCUTELLUM AND WINGS

FIGURE 19. In *tardigrade* flies, four of the tarsi (last five joints of the leg) are missing. (See Figure 20, where this is shown in connection with another character.) The anterior cross vein is missing and the fourth and fifth veins are connected by an extra cross vein at the base. In *bald,* some of the bristles are missing from the head and from other parts of the body. This is a sex-linked character. In *blunt* the scutellum is cut off squarely instead of being rounded at the posterior end, and some of the bristles are absent.

duller red than that of the wild-type fly and the conspicuous dark fleck of the latter is absent or faint.

Origin.—(R1501). Many males were obtained from a mating of bald by scute rough stump. This character had apparently been in scute rough stump stock, but had not been detected owing to the presence of rough.

Comparison.—Red might be compared with various dark eye colors of other species, but in the absence of associated characters there is little evidence to indicate homology with any of these.

Balloon (bo).

Figure 17, No. 12

Description.—In balloon, the wings have a network of extra veins between the second and third, and the fourth and fifth veins. There is also an extra vein between the second and the marginal vein and sometimes the second and the third veins are fused together instead of having the anterior cross-vein present. There is usually a broken bubble present in the network

NORMAL AND VARIANT LEGS

FIGURE 20. Above are shown the front, middle, and hind legs from the right side of a normal fly. Below are shown the legs of a mutant from called *combined*, in which four of the tarsi are absent, the one to which the claw is attached being all that is left. This fly looks about as peculiar as would a man if his hands were attached at the elbows and his feet at the knees. Other deformities also characterize the mutation.

of extra veins between the fourth and fifth veins. Generally the texture of the wing is heavy and muddy in appearance.

Origin.—(R1707). Several males and females were found in rough scalloped stock.

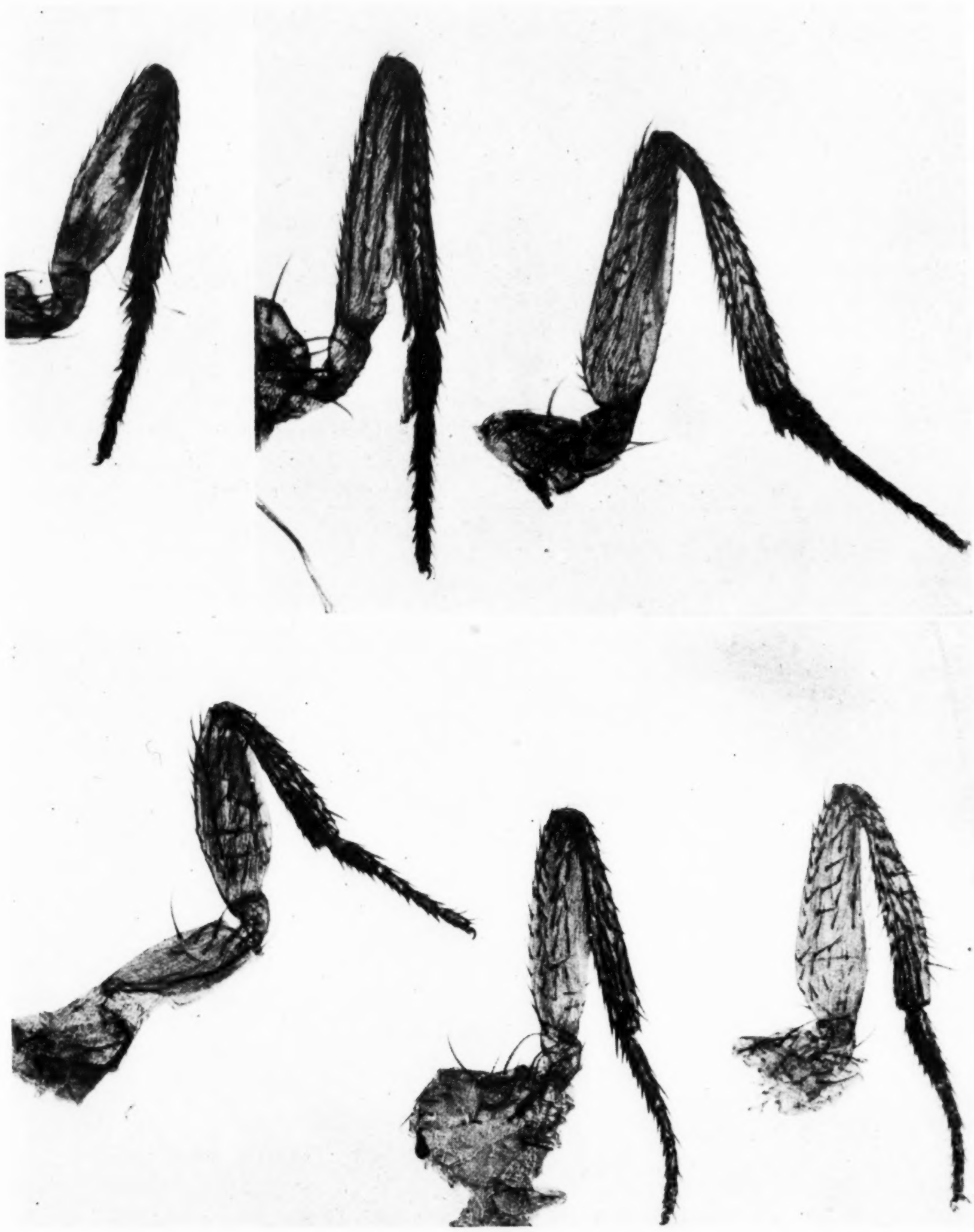
Comparison.—Balloon agrees closely with the description of balloon in *D. melanogaster* given by Bridges and Morgan,[2] but the stocks have not as yet been compared.

Third Chromosome Characters

Tardigrade (td).

Figure 19

Description.—Four tarsi are gone in tardigrade just as in combined. The anterior cross-vein is usually missing, and the fourth and fifth veins are fused or connected by an extra cross-vein at the base. Tardigrade flies had poor viability and were very hard to breed, hence the stock was discarded.



TWO MUTANT CHARACTERS AFFECTING THE LEGS

FIGURE 21. Above are shown the three legs from the right side of the *cone* mutant. The first tarsus is shortened and thickened, giving it a cone shape, and the other tarsi are shorter than normal. Below are the three right legs of a fly showing the character *approximated*. The first tarsal joint of each is absent, and the others are shortened. This character also affects the wings (see Figure 17). It is maintained by some that the Drosophila "mutants" are nothing but segregates resulting from hybridization. This hypothesis is ruled out in the present case, as *D. Willistoni* occurs wild in Cuba, but is found no farther north than Florida. The stock used here has been inbred for over 200 generations and throws mutants as frequently as ever.

Origin.—(W1256, L374). Thirty-two males and females were found in an F_1 pair mating involving approximated.

Combined (co).

Figure 20

Description.—The anterior dorso-central bristles are missing; the groove between the thorax and scutellum is generally gone; and the tarsi are completely absent except for the segment to which the claw is joined. The fly breeds very poorly so that stock must be kept by using heterozygous flies.

Origin.—(W276). Two males were found in a mass culture.

Glossy (g).

Description.—The eye is very shiny as though varnished and has a black horizontal streak running through the center. The facets of the eye are irregular and more or less run together, giving the eye a roughened appearance. The flies have poor viability.

Origin.—(W716). Several males and females were found in a mating of blunt approximated by blunt spread.

Incomplete (ic).

Figure 18, No. 14

Description.—In flies of this race both cross-veins are missing, or practically so, although a piece of either one or both may be present.

Origin.—(W3079). Several males were found in forked-? stock.

Blistered (bl).

Figure 18, No. 16

Description.—The eyes of blistered flies are lens-shaped and the facets are irregular and are sometimes yellow, so that the whole eye has a blistered appearance. One or more of the dorso-central and scutellar bristles may be missing; the wings have a shiny and roughened appearance due to the irregularity of the hairs on the wing (Fig. 18); the veins are somewhat thickened and the costal hairs are also slightly irregular. The flies have poor viability.

Origin.—(W1439). A blistered stump female was found in the stock of forked rough stump.

Rounded (rd).

Figure 18, No. 15

Description.—The wings in this race are shorter and broader than normal, thus giving them a rounded appearance. The anterior cross-vein is usually missing. When it is present, the two cross-veins are nearer together than normal, due to the shortening of the wing. Both anterior and posterior cross-veins may be lacking, in which case the wing is shorter than the abdomen and is curled up from the body. The origin of the veins is often indistinct.

Origin.—(R390). Many males and females were found in a heterozygous stock carrying combined.

Absent (as).

Figure 18, No. 13

Description.—In this mutant race the posterior cross-vein is uniformly absent and the anterior one may be gone, although it is usually present. The bristles on the thorax and scutellum are often curly, and sometimes a few of the tarsi of the hind legs are swollen.

Origin.—(R1119). Three males were found in rough scalloped stock.

Granulated (gr).

Figure 17, No. 11

Description.—The wings are very shiny, but with blotchy coloring. The veins are thickened irregularly. Some of the bristles, usually the anterior dorso-centrals, are missing from the thorax, and occasionally one of the scutellars is gone. In extreme cases, one or all of the bristles and hairs are gone from the head. Also the wings are smaller than normal and the eyes may be slightly roughened. The flies have poor viability.

Origin.—(R1953). Two males and one female were found in the second generation of a mating of blunt spread by ragged.

Characters Not Yet "Placed"

The following mutant characters are known to be inherited, but their linkage relations have not yet been worked out. With the possible exception of broken, they are all autosomal characters.

Branched (br).

Description.—The usual manifestation of the character branched is a short branch running distally from the posterior cross-vein at or near its junction with the fifth vein, or a branch from the fifth vein toward the margin. All the veins are slightly thicker than usual. The character is unsatisfactory to work with, for it seldom appears in the males and it does not always appear in the females.

Origin.—(R323). One female was found in triple stock.

Lacking (l).

Description.—Lacking is distinguished by the absence of one or both of the posterior scutellar bristles, but the character is not constant and sometimes fails to be manifest.

Origin.—(R606). Several males and females were found in the second generation of a mating for small bristles.

Cone (cn).

Figure 21

Description.—The first tarsus is shortened and broadened at its base giving it a cone shape. The other tarsi are also shortened. This condition is most extreme on the hind legs, but it is also seen to a lesser degree on the other two pairs. The wings may be bent down over the abdomen, although this is not a constant characteristic. Since cone males are sterile, pure stock cannot be maintained.

Origin.—(R2011). One male was found in the third generation from a mating of blunt approximated by rough clipped.

Jaunty (j).

Description.—In jaunty flies the wings are of a very thick and opaque texture and turn up at the tip. Generally the wings do not entirely unfold.

Origin.—(R2128). Several yellow scute jaunty females were obtained from the first generation of a mating of rough rimmed stump by yellow scute.

Comparison.—Jaunty bears a general resemblance to jaunty and the jaunty-like characters in *D. melanogaster,*[2] but it cannot be identified with any particular one at present.

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Chronological List of Sex-Linked Characters in Drosophila Willistoni

Character	*Symbol*	*Parts affected*	*First Observed*	*Found by*	*Record*
Interrupted	*i*	Wing veins	March 1920	R. C. Lancefield	W1214
Bald	*bd*	Bristles and hairs	May 1922	R. M. Ferry	R789
Vermilion	*v*	Eye-color	June 1922	R. M. Ferry	R1074
Abbreviated	*ab*	Wing veins	Aug. 1922	R. M. Ferry	R1453
Broken	*bk*	Wing veins	Sept. 1922	R. M. Ferry	R1532
Crossveinless	*c*	Wing veins	Oct. 1922	C. W. Metz	R1627

Chronological List of Autosomal Characters in Drosophila Willistoni

Character	*Symbol*	*Parts affected*	*Linkage group*	*First Observed*	*Found by*	*Record*
Approximated	*a*	Wing veins and legs	II	Apr. 1919	C. W. Metz	L88
Spread	*sp*	Wings	II	May 1919	D. E. Lancefield	W18, W19
Blunt	*b*	Scutellum	II	July 1919	D. E. Lancefield	W13, W17
Tardigrade	*td*	Wing veins and legs	III	Aug. 1919	C. W. Metz	L394, W1256
Circular	*cr*	Wings	II	Nov. 1919	R. C. Lancefield	W294
Combined	*co*	Legs	III	Nov. 1919	R. C. Lancefield	W276
Knotted	*K*	Wings	II	Dec. 1919	R. C. Lancefield	W922, L581
Glossy	*g*	Eyes	III	Jan. 1920	R. C. Lancefield	W716
Incomplete	*ic*	Wing veins	III	Feb. 1920	R. C. Lancefield	W3079
Blistered	*bl*	Eyes, wings and bristles	III	May 1920	R. C. Lancefield	W1439
Clipped	*Cl*	Wings	II	Aug. 1920	R. C. Lancefield	W1828
Scalloped	*Sl*	Wings	II	Aug. 1920	R. C. Lancefield	W1854
Apterous	*ap*	Wings, scutellum, bristles, thorax	II	Nov. 1921	R. M. Ferry	R64
Branched	*br*	Wing veins	?	Feb. 1922	R. M. Ferry	R323
Rounded	*rd*	Wings	III	Feb. 1922	R. M. Ferry	R390
Lacking	*l*	Bristles	?	Mar. 1922	R. M. Ferry	R606
Absent	*as*	Wing veins	III	July 1922	R. M. Ferry	R1119
Ragged	*rg*	Wing	II	July 1922	R. M. Ferry	R1155
Red	*red*	Eye-color	II	Aug. 1922	R. M. Ferry	R1501
Balloon	*bo*	Wings	II	Nov. 1922	R. M. Ferry	R1707
Granulated	*gr*	Wings	III	Dec. 1922	R. M. Ferry	R1953
Cone	*cn*	Wings and legs	?	Jan. 1923	R. M. Ferry	R2011
Jaunty	*j*	Wings	?	Feb. 1923	R. M. Ferry	R2128

Racial Origin of Gregor Mendel

Before the war, the founder of Mendelism was usually referred to as "the Austrian monk." Following the dissolution of the old monarchy, and the constitution of the Czecho-Slovakia, I have seen him mentioned as a Czecho-Slovak. Little is known of his pedigree, and few writers have paid any attention to it. A comment on this, in a correspondence with Professor Fritz Lenz of the University of Munich, drew forth the following interesting opinion:

"If Mendel is now being claimed for Czecho-Slovakia that is another 'imperialistic annexation' which, like so many others, does not correspond to the 'self-determination of peoples.' Mendel was throughout of German origin, of a family believed to have emigrated from Bavaria. Racially, he was a mixed type, presumablyy a blend of nordic-alpine-dinaric, like most of the population of that region. He was certainly not pure Alpine in race, nor a Slav in nationality."—*P. P.*